San Francisco Bay Area Municipal Wastewater Solids Management Study

May 1975

BROWN AND CALDWELL
CONSULTING ENGINEERS
WALNUT CREEK, CALIFORNIA

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FINAL REPORT

SAN FRANCISCO BAY AREA
MUNICIPAL WASTEWATER SOLIDS
MANAGEMENT STUDY

Prepared for

BAY AREA SEWAGE SERVICES
AGENCY

Brown & Caldwell Consulting Engineers

May, 1975

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May 16, 1975

Mr. Paul C. Soltow, Jr., General Manager
Bay Area Sewage Services Agency
Hotel Claremont
Berkeley, California 94705

Dear Mr. Soltow:

In accordance with the terms of our agreement dated December 26, 1974 we are hereby submitting 200 copies of our final report for the San Francisco Bay Area Municipal Wastewater Solids Management Study. This report contains detailed information on existing wastewater solids management systems, existing and projected wastewater solids loadings, solids processing systems and constraints and criteria applicable to wastewater solids disposal or reuse operations. Several alternatives for disposal or reuse of wastewater solids are discussed and preliminary detailed cost data are presented for four regional alternatives utilizing existing practices, land application, incineration or ocean disposal methods of sludge management.

Based on the results of our study it can be concluded that more detailed information on existing management practices, existing and projected quantity and quality of wastewater solids, available land application sites, available new technologies as well as financing and institutional resources should be obtained for a comprehensive evaluation of alternative regional wastewater solids management systems in the San Francisco Bay Area. The detailed regional study should also address the question of industrial residual solids management as well as the options available for proper management of screenings, scum and grit materials removed at municipal wastewater treatment plants.

Existing wastewater solids management systems are mainly based on landfill disposal of digested and dewatered solids. Lagooning and air drying are also used at a number of treatment plants whereas only 10 percent of the present loadings are reduced by incineration method. Due to increasing refuse and wastewater solids loads the capacity of conveniently located landfills is rapidly being exhausted and wastewater management agencies will have to contend with longer transport distances for landfill disposal of wastewater solids. Also stockpiling or spreading of digested solids on limited land available near some treatment plants does not provide a long-term solution for the sludge management problem. Moreover significant resources are wasted when wastewater solids are buried in a landfill and this practice may create undesirable environmental impacts. Therefore a

comprehensive review of this problem should be undertaken on a regional basis and alternative systems with significant potential for resource recovery should be explored in detail for the study area.

We appreciate this opportunity to have been of service to you and we are looking forward to further future associations with your agency.

Very truly yours,

BROWN AND CALDWELL

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CHAPTER I

INTRODUCTION

PURPOSE AND SCOPE OF STUDY

The purpose of this study was to carry out a general overview investigation of the existing wastewater solids management practices in San Francisco Bay Area and to evaluate the general need for and the scope of a detailed regional study aimed at developing regional wastewater solids management systems in this area. Due to time and budget constraints the scope of this study was limited to an overview treatment of the following subjects: existing and projected solids quantities and qualities, alternative sludge management systems, environmental impact of various alternatives, institutional, financing, and management schemes. Information is presented on existing sludge management practices in the study area and detailed cost data are included for a number of regional sludge management alternatives. Seasonal variations in municipal wastewater solids generation and sludge management systems for discrete industrial operations are not addressed in this report.

AUTHORIZATION FOR STUDY

This study was authorized by Bay Area Sewage Services Agency (BASSA) in an agreement signed on December 25, 1974 between BASSA and Brown and Caldwell Consulting Engineers.

Acknowledgments

The consultant wishes to acknowledge the valuable help rendered by Mr. Don Hemovich, BASSA project officer, during the course of this study. Guidance and advice received from Messrs Ron Doty, Larry Freitos, Ted Gerow, Randy Werner, Lou Vagadori, Henry Hyde, John Larson, Dennis Scherzinger and Harold Singer, members of BASSA's Residuals Management Advisory Committee is also acknowledged. In addition valuable information provided by various wastewater management agencies in San Francisco Bay Area is gratefully appreciated.

PREVIOUS AND ONGOING STUDIES

Basin Plan

The Water Quality Control Plan Report for San Francisco Bay Basin[1] is in the final printing stage. This plan includes a detailed evaluation of alternative wastewater management systems for San Francisco Bay Area. Recommendations on receiving water quality standards and other aspects of wastewater management are also contained in the Basin Plan. However the subject of wastewater solids management has not been discussed in any detail in the Basin Plan.

Subregional Studies

Fifteen subregional wastewater management studies have been prepared over the past several years in San Francisco Bay Area.[2-16] However many of these studies did not deal in great detail with the subject of wastewater solids management. Only the subregional plans for Central Contra Costa Sanitary District and Fairfield-Suisun area have recommended that wastewater solids incineration facilities be incorporated in the design of the respective subregional wastewater treatment facilities. In almost all of the other subregional facilities currently under construction no irreversible commitment has been made to a given method for final disposal of wastewater solids.

East Bay Municipal Utility District (EBMUD)

During the past two years EBMUD has been reevaluating its original decision to incinerate wastewater solids. As part of this reevaluation EBMUD has conducted an extensive soil enrichment study with anaerobically stabilized solids in Solano County. This work was started in May of 1973 and is still ongoing. However in the Project Report[17] which was recently released by EBMUD it was concluded that due to unresolved questions relevant to heavy metals and pathogenic organisms involved in sludge application to agricultural lands they will proceed with solids digestions, dewatering and sanitary landfill disposal for the immediate future.

Also EBMUD in conjunction with Pacific Gas and Electric Company and the Oakland Scavenger Company has studied the feasibility of energy recovery through pyrolysis of municipal refuse and wastewater solids. Results of this study indicate that incorporation of wastewater solids in this process would increase operation and maintenance costs without generating comparable compensating benefits in energy and other usable by-products.[18]

U.S. Army Crops of Engineers Study

In 1973 the U.S. Army Corps of Engineers prepared a study entitled, Land Application Alternatives for Wastewater Management for San Francisco Bay and Sacramento-San Joaquin Delta Region.[19] The following two alternatives were considered in this study:

1. Wastewater effluent from subregional secondary treatment plants would be conveyed to land application sites for lagoon storage prior to spray irrigation.

2. Raw wastewater would be transported to land application sites for secondary treatment in aerated lagoons prior to lagoon storage and spray irrigation.

In the first plan all wastewater solids would be digested at the plants and conveyed (as a five percent slurry) to selected areas for land application and ultimate disposal. Sludge produced from the aerated lagoons in the second alternative also would be digested and stored in drying lagoons for subsequent land application. The total annual cost for land disposal of wastewater solids is estimated at 36 million dollars for the 12 county study area encompassed by the Corps study. In this study it was assumed that most of the sludge generated in

San Francisco, San Mateo, and Santa Clara counties will be transported by truck and rail to a barging station in San Francisco. Most of the sludge in Marin, Solano, and Napa counties was assumed to be transported by rail and truck to land disposal sites in Sonoma County. Sludge originating in Alameda County would be transported by truck and railroad to a barge station at Richmond and the sludge generated in north Contra Costa County would be transported over land to an area in southeastern Contra Costa County. Sludge collected at the barge stations in San Francisco and Richmond would then be transported in barges up the delta to a land disposal area located to the north of Sacramento.

Under this scheme after the sludge is dried in the storage lagoons for two years it would be applied to the farmland as dry solid soil conditioner. Dump trucks and disc harrows would be used to transport and mix the sludge into the soil.

Solid Waste Management Implementation Project

The Association of Bay Area Governments prepared a three volume report in 1973 for the Bay Delta Resource Recovery Demonstration project.[20] This proposed project would demonstrate recovery of resources from urban wastes and the use of composted refuse for island reclamation in the Sacramento-San Joaquin Delta. In this project shredded municipal refuse would be mixed with digested wastewater sludge and will be allowed to compost in windrows. Composted materials would be hauled to delta islands for levee reinforcement and for raising the level of these islands.

The California legislature has appropriated funds for implementation of a demonstration project involving the production of 1000 tons per week of composted municipal refuse and wastewater solids. The preliminary work is now in progress to obtain matching federal funds for implementation of this demonstration project.

Countywide Solid Waste Management Plans

All counties in the San Francisco Bay Area have undertaken to develop countywide solid waste management plans. Work on these plans is in varying stages of completion but the results of these planning activities were not available in time for inclusion in this study report. The Association of Bay Area Governments is also undertaking a regional solid waste management study for the entire San Francisco Bay Area.

Mountain View Gas Recovery Study

The City of Mountain View in conjunction with Pacific Gas and Electric Company and a private landfill operator is conducting a project, funded by EPA, for recovery of methane gas from sanitary landfills. In this project gases generated in a landfill are pumped through the use of wells and the heat value of these gases is determined on a regular basis. This project is currently under way but on the basis of preliminary tests it is hypothesized that wastewater sludges may contribute trace quantities of H_2S to the decomposition gases. If this hypothesis is proved through subsequent studies it may pose some questions about the advisability of sludge disposal in landfills used for gas recovery purposes.

CHAPTER II

PHYSICAL AND DEMOGRAPHIC CHARACTERISTICS OF SAN FRANCISCO BAY AREA

The San Francisco Bay Area is located on the central coast of California as shown in Fig. II-1. This area marks a natural topographic separation between the northern and southern coast ranges. San Francisco Bay Area occupies about 7,300 square miles of land, 450 square miles of water surface and over 110 miles of the California coastline. Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma counties are included within this area.

PHYSICAL CHARACTERISTICS

Topography

The topography of the San Francisco Bay Area is dominated by the Coast Ranges, a series of geologically youthful mountains, ranges and major valleys. Extending some 600 miles from Eureka to Santa Barbara, the Coast Ranges form a nearly continuous north-south barrier between the Pacific Ocean and the Central Valley. The Golden Gate provides the only break in these parallel ridges, which rise to 4,000 feet in some locations.

Climate

The Central California coast experiences essentially two seasons: a six-month wet season which begins in November and ends in April, and a dry season comprising the remainder of the year. The major factor that influences the general weather pattern is the location of a semi-permanent high pressure area over the eastern north Pacific Ocean. This pressure center moves northward in summer, holding storms well to the north of the San Francisco Area. As a result this area receives little or no precipitation during the summer months; however, during the winter the Pacific high pressure system moves southward and permits storm centers to swing across California bringing widespread storms with moderate precipitation to the area.

Wide spatial temperature variations are experienced in San Francisco Bay Area as a function of distance from the Pacific Ocean. Temporal variations in temperature are small in areas close to the ocean and increase as the distance from the sea increases.

Precipitation in San Francisco Bay Area results from large general storms which usually cover the entire area at one time. Ninety percent of the annual precipitation falls within the six-month wet season with December, January and February receiving the heaviest amounts. Average annual precipitation within the basin ranges from a low of about 12 inches near San Jose to a high of nearly 50 inches near Mt. Tamalpais.

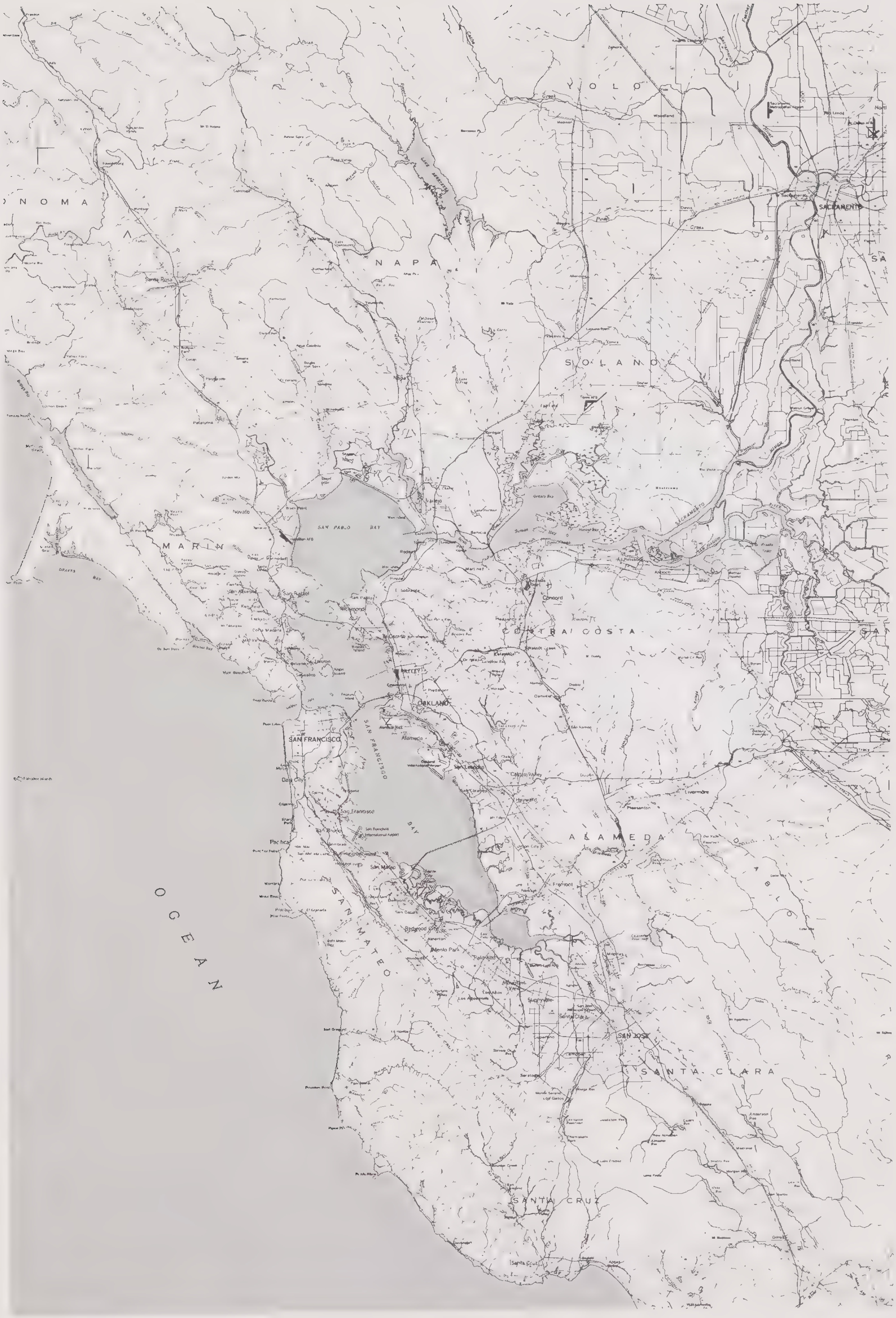


Fig. II-1. Location Map for San Francisco Bay Area

Although San Francisco Bay is separated from the Pacific Ocean by the Santa Cruz mountains and Bolinas Ridge, it is exposed to direct inflows of maritime air through the break in the hills on either side of the Golden Gate, and is markedly affected by the regime of the Pacific Ocean lying to the west. The other parts of the area are influenced by the ocean to a lesser degree, depending upon their distance from the Bay and the position of orographic barriers with respect to the flow of maritime air.

Air Quality

Climatic conditions and topographic characteristics of an area to a large extent determine the susceptibility of that area to air quality degradation. Of critical importance is the presence of temperature inversions. Temperature inversions form an effective barrier against vertical interchange of air and the upward dispersion of air pollutants.

As in other coastal area, the subsidence inversions dominate over this area most of the year. The bottom of the inversion layer varies seasonally and daily between 1,000 and 3,000 feet in elevation. Due to solar heating, the inversion usually breaks up near the extreme ends of the Sonoma and Santa Clara valleys. Wide variations in vertical mixing also occur over the extreme ends of these valleys. With the exception of early fall, late September and October, and during periods of high temperatures in April, May or June, wind circulation patterns usually provide consistent ventilation in much of the Bay Area.

In the State of California the Air Resources Control Board (ARCB) has determined the existing air quality and the potential for air quality degradation of each of the state's 11 air basins. San Francisco Bay Area is contained entirely within the San Francisco Bay Area Air Basin. This air basin includes all nine Bay Area counties. The southern counties of Bay Area consisting of Alameda, Contra Costa, San Francisco, San Mateo and Santa Clara counties have been designated by ARCB as critical air areas.

Groundwater Aquifers

In the southern reach of San Francisco Bay two aquifers, more or less indistinguishable from each other, were formed from continental deposits subsequently overlain by recent alluvial material. Along the valley fringes the aquifers are composed of gravelly and sandy alluvial-fan deposits; fine-grained deposits become interspersed with gravelly channel deposits near the center of the aquifers. The coarser materials tend to thin out and become separated and confined by thick clayey layers as the formation approaches the Bay.

Three distinct aquifers occur along the northeastern side of the South Bay in a region stretching from about Irvington in the south to the San Leandro-San Lorenzo area on the north. These formations are confined and separated by relatively impermeable blue-clay layers and are wedge-shaped, being relatively thick and extensive inland and tapering bayward.

In the Central and North Bay Areas groundwater aquifers are of limited scope and importance. One comparatively large aquifer on the east side of the Bay is composed of old alluvial deposits overlaid with more recent fine-grained alluvial deposits and by sediments. This formation outcrops along the western edge of the Berkeley Hills and extends westward beneath the Bay where it is covered by 25 to 100 feet of Bay mud.

The principal aquifers adjacent to San Pablo Bay underlie the alluvial plains of the Petaluma, Sonoma and Napa valleys. In the Petaluma Valley the principal groundwater body occurs in the old alluvial deposits which underlie the valley as well as the recent alluvial and mud deposits existing near the Bay. The aquifier has a depth which varies from 75 to 150 feet on the valley floor and 75 to 250 feet near the Bay.

The principal aquifers of the Sonoma and Napa valleys are similar in nature, consisting of alluvial deposits of recent geological age supported by volcanic and continental deposits having low water yields. No groundwater exchange is detectable between the aquifers of the two valleys, nor with aquifers located outside of their respective drainage areas.

Soils

Soils within the Bay Area vary in physical and chemical properties in accordance with differences in parent material, method of formation or deposition, and age or degree of development since their deposition. The soils may be divided into three broad groups: (1) residual soils, (2) soils that fill inland valleys, and (3) recent alluvial soils.

Residual soils include those which have been developed in place on consolidated bedrock of sedimentary, igneous, and metamorphic origin. Soils in this category are found throughout the area on steeper slopes where drainage is generally good and soils are usually shallow and of medium texture.

The soils that fill inland valleys, such as are found in the Livermore-Amador Valley area, generally occupy intermediate elevations between residual soils and recent alluvial soils.

DEMOGRAPHIC CHARACTERISTICS

Population

Basic population data for the counties include in this study have been adopted from the State Department of Finance (DOF) population projections.[21] Three sets of projections developed by DOF and reflecting differing assumptions regarding natural population changes and net migration have been used in developing the basin plans. The assumptions incorporated in the DOF projections, in terms of fertility rate and net annual immigration are as follows: the lower E-0 projection combines an assumed fertility rate of 2.11 birth per woman with a net migration of zero for the State through year 2000. For D-150 projections a fertility rate of 2.5 and a net in migration to the State increasing from a low of 29,000 in 1969-70 to 150,000 in 1980-2000 period is assumed. The base line or D-100 projections assume a future level of fertility of 2.5 birth per woman and an average annual net migration of 100,000.

In 1970 the nine counties which comprise the greater San Francisco Bay Area had a population of 4.6 million persons, about 23 percent of California's total population. Alameda and Santa Clara counties each had over one million persons or about one-fourth of the Bay Area population. At the other extreme, Napa County had only about 80,000 persons which is less than two percent of the Bay Area population.

The combination of E-0 and D-150 projections by DOF shows the study area populations increasing from 4.64 million persons in 1970 to 5.96 million persons in the year 2000 (Table II-1). This increase represents an average annual (compounded) growth rate of 1.0 percent; for an overall increase of 28 percent.

The three northern counties are expected to experience the most rapid growth. From 1970 to year 2000 the projected growth rates for Sonoma, Solano and Napa counties are expected to be about three percent per year. Alameda and San Mateo counties with annual growth rates of 0.6 and 0.1 percent, respectively, are expected to experience the slowest growth rates, while the resident population in the City and County of San Francisco is expected to decrease about four percent.

Land Use

The nine county San Francisco Bay Area covers some 4.5 million acres of land and in 1970 residential uses occupied 10 percent of this area. This use will increase to about 20 percent in year 2000. Land area devoted to commercial uses is expected to increase by 29 percent over the same period. Commercial uses, when viewed as population-serving uses, correspond to the projected increases in residential land use and the associated population increases. Industrial land use acreage is expected to increase from 3 percent to 4.5 percent of the total land area by year 2000. Only a small increase of about 2 percent in the net irrigated area is expected to occur in this area through year 2000.

Table II-1. Population Projections by County[a]

County	Projection Level	1970	1980	1990	2000
Alameda	E-O, Baseline	1,076	1,122	1,172	1,196
	D-150	1,076	1,148	1,271	1,400
Contra Costa	E-O, Baseline	559	639	722	784
	D-150	559	657	796	929
Marin[b]	E-O	207	229	249	262
	Baseline	207	260	300	340
	D-150	207	234	272	305
Napa	E-O	79	98	108	114
	Baseline, D-150	79	104	140	177
San Francisco	E-O, Baseline	714	651	622	600
	D-150	714	666	674	690
San Mateo	E-O, Baseline	556	584	609	616
	D-150	556	593	641	671
Santa Clara	E-O, Baseline	1,074	1,309	1,482	1,590
	D-150	1,074	1,345	1,632	1,859
Solano	E-O	174	193	219	244
	Baseline, D-150	174	202	261	350
Sonoma	E-O	205	287	335	374
	Baseline	205	301	395	478
	D-150	205	302	420	542
Basin Total	E-O	4,644	5,112	5,518	5,757
	Baseline	4,644	5,157	5,629	5,962
	D-150	4,644	5,251	6,107	9,926

[a]Population in thousands.

[b]Baseline projections based on local population projections.

Source: "Population Projection for California Counties 1975-2020", California State Department of Finance, June, 1974.

CHAPTER III

WASTEWATER SOLIDS CHARACTERISTICS

Wastewater contains numerous solids which are usually characterized in groups by the process employed to remove them from the liquid flow. Although these solids are not always removed separately, the most common groups, in order of their normal removal sequence, include screenings, grit, scum, primary sludge and secondary sludge. Chemical sludges are also sometimes involved, either separately or in combination with primary or secondary sludges.

Physical Characteristics

Screenings. Screenings include organic and inorganic debris of every conceivable description which is large enough to be retained on bar racks set with one-half inch and larger clear openings between the bars. Often even small debris is retained by being captured within the larger material. Many times this type of solid is simply cut up and disintegrated within the liquid flow. When it is removed from the flow the debris is usually in a sufficiently undisturbed condition to be easily recognized as to source, has a high organic content (85-90 percent volatile), is completely saturated (90-95 percent moisture) and has a specific gravity of 1.0. These characteristics make the separate manual handling of this material a very difficult and extremely unpleasant task. Separate screenings removal is normally limited to those processes where it is required to protect downstream solids treatment and disposal systems, for separate disposal screenings require further dewatering to approximately 70 to 75 percent moisture. The volume of screenings removed during the treatment process varies from 1.6 to 16.25 cubic feet per million gallons of sewage.[22]

Grit. Grit includes those heavier inorganic solids which are easily separated from the liquid flow by relatively short duration high velocity settling facilities. Usually grit solids are removed prior to primary sludge collection; however, some smaller plants do remove these solids from the liquid flow together with the primary sludge and then separate them prior to providing further solids treatment. In order to maximize primary sludge concentration during its initial separation from the liquid flow grit must be removed separately. Grit solids are limited to material with particles larger than those that will pass through a 150 mesh sieve. This is due to the difficulty in separating particles of smaller size from the heavier weight fraction of the organic matter. Even with the best removal systems the grit will usually contain considerable organic matter (30-50 percent volatile matter), will maintain a specific gravity of only about 1.6 (100 pounds per cubic foot), and solids contration of the grit will depend on the method selected for its removal and disposal. When separately removed and properly dewatered, it will usually contain from 60 to 70 percent solids. The volume of grit removed during treatment processes varies from 1 to 14 cubic feet per million gallons of sewage.[22]

Scum. Scum consists of floatable trash which is removed from the relatively quiesent surfaces of primary and secondary sedimentation tanks. Scum material may include water, vegetable and mineral oils, grease, hair, rubber goods, animal fats, waxes, free fatty acids, calcium and magnesium soaps, seeds, skins, bits of cellulosic material such as wood, paper or cotton, cigarette tips, plastic suppositories and pieces of garbage. The heterogenous composition may be quite variable from time to time. Scum is usually collected and removed and treated with the primary sludge. Sometimes it is handled separately to assure the reliability of the primary sludge treatment system. Proper scum removal equipment will minimize its water content, usually maintaining a 4 to 6 percent solids concentration. Scum will normally have a specific gravity of less than 1.0, usually about 0.95, and will have an extremely high organic content (95 percent volatile). Separate disposal by incineration requires thickening the scum to a 60 percent solids concentration. Scum removed during the treatment process varies from 48 to 180 pounds (dry weight) per million gallons of sewage.[22]

Primary Sludge. Primary sludge as produced by primary sedimentation and/or chemical treatment usually behaves like an inorganic solid. Although mostly organic in composition, this sludge contains the easily settleable or chemical precipitated material in the wastewater. Depending on the method of treatment selected, primary sludges may also contain disintegrated screenings, grit or scum. The color of this slimy liquid varies from grey to black depending on its "freshness". Primary sludge generally is removed from the liquid flow with a 4 to 6 percent solids concentration. The sludge tends to be odoriferous, especially when it becomes septic, usually contains a fair amount of organic material (60 to 80 percent volatile), and has a specific gravity of approximately 1.02-1.05. If grit is not removed separately this specific gravity can increase to 1.10 or 1.15. Average primary sludge production is estimated at 1,500 lbs of solids per million gallons of sewage.[3] Data on primary sludge production in San Francisco Bay Area are presented in Table IV-1 of Chapter IV. These data indicate a range varying from 400 to 2,000 lbs of solids per million gallons of sewage but the majority of primary treatment plants reported a production rate of 1,200 to 1,600 lbs of solids per million gallons of sewage.

Secondary Sludge. Secondary sludge is always of a biological nature although under some special conditions it can also contain chemical precipitates. These biological sludges are most commonly produced by the activated sludge and trickling filter secondary treatment processes. The darkness of their brown color will depend on operating conditions. Both waste activated sludge and trickling filter humus are flocculent, but they differ greatly in density. Activated sludge is difficult to settle and, consequently, is always lowest in solids concentration when removed from the liquid flow (0.5 to 2.0 percent solids). Filter humus is high in density, settles readily and usually forms a thick 4 to 7 percent slurry. Both of these biological sludges when properly handled have relatively inoffensive odor when fresh. Secondary sludge organic content will vary in relation to the degree of oxidation achieved in the secondary treatment process. Because of its high organic content, secondary sludge specific gravity is just slightly above 1.0. Sludge is produced at an average rate of 2,750 lbs of solids per million gallons of sewage from the combined primary sedimentation and carbonaceous oxidation processes. Data on secondary sludge production in San Francisco Bay Area are

reported in Table IV-1, Chapter IV. These data indicate a range varying from 1,000 to 3,000 lbs of solids per million gallons of sewage but the majority of treatment plants reported a production rate of about 2,500 lbs of solids per million gallons of sewage.

Chemical Characteristics

Screenings, grit and scum chemical characteristics are usually insignificant to either the liquid or solids treatment processes. It is important, however, that the consolidation and concentration of nutrients and metallic elements which takes place in the primary and secondary sludges be fully recognized. Table III-1 provides some typical values for the nutrient levels found within the sludges. Data from the BASSA questionnaire submitted to dischargers (with a 70 percent response from municipal dischargers) indicate that only 8 of 55 responding dischargers have any detailed chemical analysis of their sludge. Data on chemical constituents of digested sludge for three treatment plants in the San Francisco Bay Area is presented in Table III-2. These data indicate a wide range of concentrations for three plants representing heavy industrial discharges (EBMUD), medium industrial discharges (Union Sanitary District) and low industrial discharges (City of Pleasanton). Concentration of most heavy metals reported in Table III-2 increases with the level of industrial discharges into the wastewater treatment plant. Therefore implementation of source control programs may result in significant reductions in the concentration of heavy metals contained in wastewater solids produced at treatment plants receiving wastewater from heavily urbanized areas.

Table III-1. Typical Composition of Raw Sludge [a]

Characteristics	Primary sludge	Secondary	
		Waste activated sludge	Biofilter humus
Total dry solids, percent	2.0-7.0	0.5-1.2	4.0-7.0
Volatile solids, percent of total solids	60-80	65-85	50-80
Nitrogen (N), percent of total solids	1.5-4.0	2.3-6.0	1.5-5.0
Phosphorus (P_2O_5), percent of total solids	0.8-2.8	2.8-11.0	1.4-4.0
Potassium (K_2O), percent of total solids	0-1.0	0-1.0	Not available

[a] Source: Reference 21

Table III-2. Composition of Selected Digested Sewage Sludges in San Francisco Bay Area [a]

	EBMUD [b]	Union S. D. [c]	City of Pleasanton [c]
Type of sludge	Primary	Secondary	Secondary
Level of sludge treatment	Anaerobic digestion	Anaerobic digestion	Anaerobic digestion
Total Solids	7.0%		1.55%
Volatile Solids	3.0%		
Alkalinity (as $CaCO_3$)	4,500 mg/l		
Conductivity	5.4 mmhos/cm		
Cl	4,430		
TKN	42,700		
NH_3-N	11,500		
P	13,900		
K	2,400		
Ag	15		
As	7		
B	77		768
Ba	112		
Ca	8,900		
Cd	40	12	10.5
Co	45		
Cr	1,600	385	559
Cu	730	730	
Fe	40,290	7,793	8.9
Hg	2.5		
Mg	6,715		
Mn	480	164	
Mo	41.5		
Na	6,215		272,000
Ni	270	48	66
Pb	1,000	995	184
Se	0.8		
V	55		
Zn	4,700	2,398	1,580
Zn/Cd ratio	117	200	150
Cn^-	-	12	-

[a] The units are in mg/kg oven dry weight unless otherwise indicated.

[b] Average for three grab samples obtained at various times during the year

[c] Grab samples

CHAPTER IV

EXISTING MUNICIPAL WASTEWATER SOLIDS HANDLING SYSTEMS IN SAN FRANCISCO BAY AREA

EXISTING TREATMENT AND DISPOSAL SYSTEMS

Detailed data on existing sludge treatment and disposal methods in San Francisco Bay Area is presented in this chapter. Much of this data was obtained from questionaires submitted by BASSA to municipal dischargers in the San Francisco Bay Area. Additional information was developed through contacts with various dischargers and from published data in the subregional reports as well as the preliminary draft of the comprehensive water quality management report for San Francisco Bay Basin.

No detailed data is presented on the quantity or treatment and disposal practices for scum, screenings and grit removed during sewage treatment processes. However from representative data presented in Chapter III it can be concluded that the amount of screenings removed from municipal wastewaters in the study area may range from 31 to 320 cubic yards per day. Scum production may range from 13 to 49 tons per day whereas the quantity of grit removed in sewage treatment plants may range from 20 to 276 cubic yards per day. More definitive data on grit, scum and screening removal rates need to be developed in the course of any subsequent wastewater solids management study. Treatment and disposal practices for screenings, grit and scum varies from plant to plant, however no data were collected on these practices during the course of this study. A detailed evaluation of these operations should also be carried out in the planned regional study. However in general scum is handled with primary sludges whereas screenings are either barminuted and returned to the wastewater stream or are disposed of by incineration or landfilling methods. Grit is normally disposed of by landfilling method.

A variety of industries are located in San Francisco Bay Area and some of these industries generate various types of sludges through their production processes. Since no basin wide survey of industrial wastewater residual solids has been undertaken in the Bay Area there is a lack of data on this important aspect of sludge management. Due to time and budgetary constraints no data were collected on industrial sludge loadings or treatment and disposal practices in the course of this study. However the question of industrial solids handling and disposal practices must also be addressed in the planned regional study.

The following symbols are used in this chapter to identify various sludge treatment processes currently practiced in the study area.

Process	Symbol
Aerobic digestion	Ae D
Anaerobic digestion	An D
Centrifugation	C
Composting	Co
Dissolved air flotation	Da F
Drying beds	Db
Dewatering (gravity)	Dw
Elutriation	E
Incineration	I
Lagooning	L
Pressure filtration	Pfi
Thickening	T
Vacuum filtration	Vf
Wet oxidation	Wo

Summary data on existing sludge management practices in San Francisco Bay Area is presented in Table IV-1. A brief discussion on sludge management practices in each subregion in this area is presented in the following sections.

ALAMEDA COUNTY

Alameda Creek Subregional Area

The City of Livermore treatment plant, which is currently under expansion, is a secondary activated sludge plant utilizing both drying beds and lagoons for treatment of anaerobically digested sludge. The portion of the sludge going to the drying beds is eventually used as a soil conditioner by the Livermore Parks and Tree Department. Lagoon storage capacity is being enlarged in order to accommodate present and future sludge loads. Sludge from the Pleasanton treatment plant is digested and transported by tanker truck for disposal in a local sanitary landfill. Valley Community Services District discharges an aerobically digested sludge to lagoons. These lagoons are periodically cleaned and the sludge is disposed of through land spreading operations.

East Bay Subregional Area

EBMUD is presently upgrading its primary treatment facility to secondary level. At this plant sludge is digested, vacuum filtered, and trucked to the West Contra Costa County disposal site where it is disposed of in a landfill by mixing it with intermediate soil cover. At the City of Hayward treatment plant thickened sludge is digested and discharged to lagoons. A sludge contractor removes the sludge from the lagoons, and after composting, markets the final product as a soil conditioner. Oro Loma Sanitary District utilizes digestion, elutriation, vacuum filtration and lagoons for treatment of sewage sludge. With its incineration facilities presently out of service, Oro Loma disposes of sludge loads largely by landfilling on land adjacent to the treatment plant. However plans call for reactivating the incinerator in the near future. Local residents use a portion of this sludge for soil

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
Alameda County																
Alameda Creek Subregion																
Livermore	4.3	secondary	102	5	96.5	118	7.5	3	60	7.7	AnD, Db, L	Soil conditioner	Continual partial demand	Parks Dept.	Truck	Variable
Pleasanton	1.25	secondary	20	1.5	92.5	23.3	1.8	.1	94	2.1	AnD	Landfill	32 years	City Dump	Truck	2½ mi.
Valley Community Services District	3.7	secondary	106	4.30	97	123	4.3	2.6	94	4.4	AnD, L	Land disposal	Continual capacity	On site	Truck	On site
Subtotal	9.25	-	228	8.3	-	264.3	52.5	5.7	-	14.2						
East Bay Subregion																
EBMUD	85	primary	1220	73	94	1372	66	16.5	75	75	AnD, Vf	Landfill	50 yrs. years	West Contra Costa Co. Landfill	Truck	15 mi.
City of Hayward	12.5	secondary	315	14.5	98	366	78.1	8.5	94	80	T, AnD, L, Co	Soil conditioner	Continual demand	Taken by sludge contractor	Truck	Variable
Oro Lomo Sanitary District	13	secondary	425	17	96	494	35.5	7.1	80	44.3	AnD, E Vf, L, I	Landfill	Limited capacity	On site	Truck	Variable
City of San Leandro	7.5	secondary	213	10.6	95	247	13	2.2	83	13.3	T, AnD, C, Db, L	Landfill, Soil conditioner	Approx. 6 to 8 years, Continual partial demand	San Leandro Dump, City Parks Dept.	Truck	½ mi.

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
Union Sanitary District																
Alvarado Plant	3.6	secondary	91	3.7	96	106	3.8	1.5	60	4	AnD, L, Db	Soil conditioner	Continual demand	Nurseries	Truck	Variable
Newark Plant	5.35	secondary	121	3.6	97	141	6.6	2.7	60	6.8	AnD, C, Db	Soil conditioner	Continual demand	Nurseries	Truck	Variable
Irvington Plant	6.49	secondary	133	4.6	96.5	154	8.3	3.3	60	8.4	AnD, L, Db	Soil conditioner	Continual demand	Nurseries	Truck	Variable
Subtotal	133.44	-	2478	104.8	-	2880	221.3	40	-	251.9						
Total, Alameda County	142.69	-	2706	113.1	-	3144.3	273.8	45.7	-	266.1						
Contra Costa County																
City of Antioch	2.28	primary	40.1	1.2	97	46.6	2.1	.9	60	2.1	AnD, Db, L	Lagoons	10 years	On site	Piped	On site
City of Brentwood	.45	secondary	5.6	.3	95	6.5	.4	.2	60	.2	AnD, L, Db	Soil conditioner	Continual demand	On site	Truck	On site
CCCSD	24	primary	340	18.7	94.5	395.3	22.6	9.0	60	22.8	AnD, Db	Soil conditioner	Continual demand	Taken by sludge contractor	Truck	Variable
City of Concord[1]	5	secondary	78.4	3.9	95	91.2	2.8	.6	78	2.9	T, C, I	Sedimentation Pond	Continual capacity	On site	Piped	On site
Crockett-Valona	.20	primary	5.1	.2	96	5.9	.2	.1	60	.2	AnD, Db	Soil conditioner	Continual demand	Local residents	Private auto, truck	Variable
Mountain View SD	.60	secondary	7.5	.4	95	8.7	.6	.2	60	.6	T, AnD, Db, Co	Landfill, Soil conditioner	50 yrs, Continual partial demand	West CCC Landfill Local residents	Truck	Variable
City of Pinole	1.3	secondary	38	1.5	96	44.2	2.3	.9	60	2.3	T, AnD, C	Landfill	50 yrs	West CCC Landfill	Truck	7 mi.
Oakley	0.1	primary	NA													
CCCSD #15	0.14		NA													
CCCSD #19	0.15		NA													

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
City of Pittsburg																
Camp Stoneman Plant	.70	primary	4.3	.4	94.5	5.0	3	2	60	3.1	Dw, AnD, Db	Land disposal	5 years	On site	Truck	On site
Montezuma Plant	2.0	primary	6.4	1.25	94.5	7.4	4.5	.69	60	4.6	Dw, AnD, Db	Land disposal	10 years	On site	Truck	On site
Richmond Municipal Sanitary District	8.0	secondary	255	12.5	95.5	296.5	38.4	6.9	80	48	Pfl, T, AnD, E, Vf	Landfill	50-75 yrs	West CCC Landfill	Truck	9 mi.
Rodeo Sanitary District	.85	secondary	24.9	1.0	96	29.0	1.5	.6	60	1.5	And, Db	Soil conditioner	N A	N A	N A	N A
San Pablo Sanitary District	6.0	secondary	175.5	7.0	96	204.1	113.3	4.53	60	115.6	T, AnD, Db	Landfill, Soil conditioner	50 yrs, Continual partial demand	West CCC Landfill	Truck	Variable
CCCSD 7A	.90	primary	11.3	.6	95	13.1	.8	.3	60	.8	AnD, Db	Soil conditioner	Continual demand	Clayton Jail Farm	Truck	10 mi.
Total, Contra Costa County	52.57	-	992.1	46.9	-	1153.5	192.5	68.8	-	204.7						
Marin County																
Central Marin Subregion																
Sanitary District No. 1	4.5	secondary	31.0	1.6	95	36	3.6	.7	80	4.5	AnD, C	Soil conditioner	Continual demand	Variable	Truck	Variable
San Quentin Prison	.60	primary	7.5	.4	95	8.7	.2	.1	60	.2	AnD, Db	Soil conditioner	Continual demand	On site	Truck	On site
San Rafael Sanitary District	2.8	secondary	82	3.3	96	95.3	14	3.9	72	14.3	T, AnD, C, Db	Landfill	50 yrs	West CCC Landfill	Truck	10 mi.
Subtotal	7.90	-	120.5	5.3	-	140	17.8	4.7	-	19						

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
North Marin - South Sonoma Subregion																
Hamilton Air Force Base	.18	secondary	2.8	.1	95	3.3	.2	.1	60	.2	AnD, Db	Landfill, soil conditioner	Continual capacity	On site	Truck	On site
Las Gallinas Valley Sanitary District	2.2	secondary	40.4	1.6	96	47.0	2.1	.8	60	2.1	AnD, C	Soil conditioner	Continual demand	County land	Truck	Variable
Marin County Sanitary District No. 6	3.3	secondary	96.5	4.8	95	112.2	5.4	1.1	80	5.5	T, AnD, C, L, Db	Soil conditioner	Continual demand	Adjacent to plants	Truck	Sites are adjacent to plants
San Rafael Sanitation District	.12	secondary	1.5	.10	95	1.7	.1	.04	60	.1	AnD, Db	Soil conditioner	Continual demand	On site	Truck	On site
Subtotal	5.80	-	141.2	6.6	-	164.2	7.8	2.04	-	7.9						
Southern Marin Subregion																
Marin County Sanitary District No. 5	.648	primary	8.1	.4	95	9.4	.2	.1	55	.2	AnD, Vf	Soil conditioner	Continual demand	Local residents	Private autos, trucks	Variable
City of Mill Valley	1.6	secondary	30	1.6	94.5	34.9	2.8	1.1	60	2.9	AnD, C, Db	Landfill, Soil conditioner	Limited capacity Partial demand capacity	On site, local residents	Truck	On site, variable
Richardson Bay Sanitary District[1]	.25	secondary	3.1	.2	95	3.6	.4	.2	60	.4	T, C, I	Sedimentation ponds, then landfill	Limited capacity	On site	Piped	On site
Sausalito - Marin City	1.8	primary	4.3	.2	95	4.9	2.4	.7	72.5	2.0	AnD, Vf	Soil conditioner	Continual demand	County land	Truck	Variable
Subtotal	4.298	-	45.5	2.4	-	52.8	5.8	2.1	-	5.5						
Total, Marin County	18.0	-	307.2	14.3	-	357	31.4	8.84	-	32.4						

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
Napa County																
Napa-Vallejo Subregion																
Napa Sanitary District	5.0	secondary	62.5	2.0	95	72.7	3	1.2	60	3.1	AnD, C, Db, L	Land disposal, soil conditioner	Limited capacity	On site	Truck	On site
American Canyon CWD				None									Continual partial demand	Variable		Variable
Subtotal	5.0	-	62.5	2.0	-	72.7	3	1.2	-	3.1						
Upper Napa Valley Subregion																
City of Calistoga	.35	secondary	4.4	.2	95	5.1	1.4	.6	60	1.4	AeD, AnD Db, L	Land disposal	Continual capacity	On site	Truck	On site
City of St. Helena	0.3	secondary		None												
City of Yountville	.12	secondary	1.9	.1	95	2.2	.1	.3	60	.1	AnD, Db	Land disposal	Continual capacity	Yountville area	Truck	Variable
Subtotal	.47	-	6.3	.3	-	7.3	1.5	.9	-	1.5						
Total, Napa County	5.47	-	68.8	2.3	-	80	4.5	2.1	-	4.6						
City and County of San Francisco																
North Point Plant	63	primary	1628	70.0	95.7	1893	275	49.5	82	343.8	T, AnD, Vf	Landfill	8-10 years	Mt. View Dump	Truck	30 mi.
Southeast Plant	23	primary														
Richmond Sunset Plant	20	primary	272.7	9	96.7	317.1	9	2.5	72	11.3	T, AnD, Vf	Soil conditioner	Continual demand	Golden Gate Park	Truck	2 mi.
Total, San Francisco County	106	-	1900.7	79	-	2210.1	284	52	-	355.1						
San Mateo County																
South San Francisco–San Bruno	8.5	secondary	248.6	12.4	95	289.1	14.9	6.0	60	15.2	T, AnD, C, Co	Soil conditioner	Continual demand	Tillo Products	Truck	Variable
San Francisco Airport	.83	secondary	14	.7	95	16.3	2.9	.2	94	3.6	AnD, Vf	Landfill	Limited capacity	On site	Truck	On site
City of Millbrae	2.3	secondary	67.3	3.4	95	78.3	8.5	1.0	88	8.7	T, AnD, C	Landfill	$4\frac{1}{2}$ years	South County Disposal District	Truck	17 mi.

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
City of Burlingame	4.2	secondary	110	5.5	95	128.0	7.4	2.9	60	7.6	Dw,T,Wo, AnD,Db	Landfill	$2\frac{1}{2}$ years	Menlo Park Dump	Truck	
City of San Mateo[1]	10.5	primary	131.3	6.6	95	152.7	25	7.5	70	25.5	T, C, I	Landfill	3-5 years	City Dump	Truck	1 mi.
Foster City	2.0	primary	16.7	1.5	91	19.4	N.A.	N.A.	N.A.	N.A.	C	Landfill	25 years	San Jose Dump	Truck	25 mi.
Belmont-San Carlos	5.1	secondary	63.8	3.2	95	74.2	6.6	1.7	75	6.5	AnD, C	Landfill	$4\frac{1}{2}$ years	South County Disposal District	Truck	3 mi.
Redwood City	7.8	secondary	122.3	6.1	95	142.2	8.5	2.1	75	8.7	AnD, C	Landfill	$4\frac{1}{2}$ years	South County Disposal District	Truck	3 mi.
Menlo Park Sanitary District	5.80	secondary	108.4	7.6	93	126.0	10.2	4.1	60	10.4	AnD, C	Landfill	$4\frac{1}{2}$ years	South County Disposal District	Truck	1/8 mi.
North San Mateo County Sanitation District	6.0	primary	60.1	3.0	95	70.6	11.4	2.3	80	11.6	Dw, T, AnD, C	Landfill, soil conditioner	Continual demand	City Dump & turf areas	Truck	Variable
City of Pacifica	3.5	primary	68	3.4	95	79.1	4.9	1.0	80	5.0	AnD, C	Landfill	$4\frac{1}{2}$ years	South County Disposal District	Truck	27 mi.
Montara Sanitary District	.25	secondary	3.1	.2	95	3.6	.2	.1	60	.2	AnD,Db	Soil conditioner	Continual demand	Local residents	Private auto, truck	Variable
Granada Sanitary District	.27	primary	3.4	.2	95	4.0	.3	.1	60	.3	AnD, Db	Soil conditioner	Continual demand	Local residents	Private auto, truck	Variable
City of Half Moon Bay	.36	secondary	10.5	.5	95	12.2	.3	.1	60	.3	AeD, Db	Soil conditioner	Continual demand	Local residents	Private auto, truck	Variable
Total, San Mateo County	57.41	-	1027.5	54.3	-	1195.7	101.1	29.1	-	103.6						

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
Santa Clara County																
South San Francisco Bay Subregion																
City of Palo Alto[1]	25	secondary	731.3	29.3	96	850.3	25	5	80	25.5	Dw,C,I	Landfill	6-8 yrs	Palo Alto refuse site	Truck	¼ mi.
San Jose-Santa Clara	80	secondary	3013	75.3	97.5	3503	933	56	94	952	Daf, AnD, L	Soil conditioner	Continual partial demand 7 yrs.	On site, variable	Piped, truck	On site, variable
City of Sunnyvale	16.5	secondary	206	10.3	95	240	103	6.18	94	105	AeD, AnD, Db (some)	Lagoons	Continual capacity	On site	Piped	On site
Gilroy-Morgan Hill	3.1	primary	38.6	1.9	95	44.9	2.9	1.16	60	3.0	AnD, Db	Soil conditioner	Continual partial demand	Local residents	Truck	Variable
Total, Santa Clara County	124.60	-	3988.9	116.8	-	4638.2	1063.9	68.34	-	1085.5						
Solano County																
Benicia Subregion																
City of Benicia	1.2	primary	15	.8	95	17.4	1.1	.5	60	1.1	AnD, Db	Soil conditioner	Continual demand	City Parks Dept.	Truck	Variable
Subtotal	1.2	-	15	.8	-	17.4	1.1	.5	-	1.1						
Fairfield-Suisun Subregion																
Cordelia	.20	secondary	2.6	.1	95	3.0	.2	.1	60	.2	Db	Landfill, soil conditioner	Continual demand	Dump, local residents	Truck	15 mi.
Fairfield-Suisun Sanitary District[1]	4.3	primary	53.8	2.7	95	62.5	3.0	.9	70	3.1	T,C,I	Landfill	Continual capacity	On site	Piped	On site
Travis Air Force Base	1.6	secondary	20.8	1.0	95	24.2	1.5	.6	60	1.5	AnD, Db	Land disposal	Continual capacity	On site	Truck	On site
Subtotal	6.10	-	77.2	3.8	-	89.7	4.7	1.6	-	4.8						

Table IV-1. Existing Municipal Sludge Treatment Facilities and Loadings in San Francisco Bay Area (Continued)

Sewerage Agency	Treatment plant		Raw sludge				Treated sludge				Sludge treatment process[a]	Disposal method			Transportation method	
	ADWF, mgd	Treatment level	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day	Total quantity, tons/day	Dry solids, tons/day	% Water	Total volume, cu yd/day		Type	Remaining capacity	Location	Type	Distance to disposal site
Napa-Vallejo Subregion																
Mare Island	.60	primary	7.6	.4	95	8.8	.6	.2	60	.6	AnD,Db	Landfill	Continual capacity	On site	Piped	On site
Vallejo Sanitary District and FCD	7.5	primary	76.5	3.0	96	89	46.9	2.8	94	47.9	Dw,AnD	Soil conditioner	Continual demand	Variable	Truck	Variable
Vacaville	4.6	secondary	N/A	N/A		N/A					AnD,L	Storage in lagoons	7-8 yrs.	On site	Piped	On site
Dixon	.35	oxidation ponds	none													
Subtotal	8.45	-	84.1	3.4	-	97.8	47.5	3.0	-	48.5						
Total, Solano County	20.35	-	176.3	8.0	-	204.9	53.3	5.1	-	54.4						
Sonoma County																
North Marin-South Sonoma Subregion, Sonoma County																
City of Petaluma	3.5	secondary	75	3.0	96	87.2	5.7	1.1	80	5.8	AnD,AeD,C	Landfill	Continual capacity	On site	Truck	On site
Sonoma Valley County Sanitary District	1.8	secondary	58.4	2.9	95	68	21	.8	96	21.4	AnD,L	Landfill, soil conditioner	Continual demand	On site	Truck	On site
Subtotal	5.3	-	133.4	5.9	-	155.2	26.7	1.9	-	27.2						
North Sonoma Subregion																
City of Santa Rosa																
Laguna Plant	2.5	secondary	73.1	2.9	96	85	29.1	.7	97.5	29.7	AeD	Land disposal	Continual capacity	On site	Piped	On site
West College Plant	6.5	secondary	101.9	2.0	98	118.5	75.9	1.1	98.5	77.4	AnD,L	Soil conditioner	Continual demand	City Parks, local residents	Truck	Variable
Oakmont	.16	secondary	1.8	.1	95	2.1	.2	.1	60	.2	AeD,Db	Land disposal	Continual capacity	On site	Piped	On site
Rohnert Park-Cotati	1.2	secondary	8.5	.4	95	9.9	1.1	.5	60	1.1	AnD,Db	Remains in Db	Continual capacity	On site	Piped	On site
City of Sebastopol	.30	secondary	3.8	.2	95	4.4	1.9	.1	94	.1	AnD, L	Land disposal	Continual capacity	On site	Piped	On site
Healdsburg	.50	secondary			N/A											
Windsor County Water District	.30	secondary	3.8	.2	95	4.4	.3	.1	60	.3	AeD,Db	Soil conditioner	Continual demand	Local residents	Truck	Variable
Cloverdale				N/A												
Subtotal	11.46	-	192.9	5.8	-	224.3	108.5	2.6	-	108.8						
Total, Sonoma County	16.76	-	326.3	10.7	-	379.5	135.2	4.5	-	136						
Grand Total	543.85	-	11,494	445.4	-	13,364	2140	284	-	2242						

[1] These loads refer to the centrifuged sludge.
N/A - not available

conditioning purposes. Sludge treatment units used in the City of San Leandro treatment plant include thickening, digestion, centrifugation, drying beds and lagoons. Currently, raw and digested sludge are disposed of in different manners. The bulk of the raw sludge is centrifuged and is taken to a dump site in San Leandro for final disposal. Digested sludge is stockpiled after drying and is used as a soil conditioner on local golf courses. Alvarado, and Irvington treatment plants of the Union Sanitation District use digestion tanks, lagoons, and drying beds. Centrifugation is utilized at the Newark plant along with digestion tanks and lagoons. Sludge from all three plants is used by local nurseries for soil conditioning.

CONTRA COSTA COUNTY

Contra Costa County Subregional Area

In eastern Contra Costa County digestion tanks, drying beds, and lagoons are used by the treatment plants of Antioch and Brentwood. In Antioch digested sludge is retained in lagoons where sufficient storage capacity exists for approximately ten more years. In the City of Brentwood digested and dried sludge is stockpiled and is used for agricultural purposes. Camp Stoneman and Montezuma treatment plants in Pittsburg utilize gravity dewatering, digestion and drying beds. At both plants sludge is disposed of by landfilling near the plant site. At Oakley, Byron and Bethel Island treatment plants no significant quantities of sludge is produced at the present time however data is lacking on current disposal practices at these treatment plants.

The sludge produced at Central Contra Costa Sanitary District is used as a soil conditioner. Digested sludge from the drying beds is purchased by a sludge contractor and is processed for resale purposes. City of Concord currently is the only municipal discharger in the County using sludge incineration facilities. Raw sludge is thickened and centrifuged, prior to incineration, wet ash from the incinerator is discharged to a sedimentation pond. In case of incinerator breakdown, centrifuged sludge is hauled to a landfill located in Martinez. After digestion and drying on sand beds, sludge from CCCSD No. 7A is hauled to the Clayton jail farm where it is used as a soil conditioner. At Mountain View Sanitary District sludge is used as a soil conditioner during the summer whereas in the winter it is hauled to the West Contra Costa County disposal site. Sludge treatment processes used at this plant consist of thickening, digestion, drying on sand beds and composting.

In western Contra Costa County digested and air dried sludge from Crockett-Valona Sanitary District is made available to local residents for soil conditioning. Rodeo Sanitary District has sufficient capacity in their drying beds to accommodate present digested sludge loads. At the City of Pinole treatment plant thickened sludge undergoes digestion and centrifugation prior to disposal at the West Contra Costa County disposal site. San Pablo Sanitary District utilizes both landfill and soil conditioning as methods of sludge disposal. Arrangements are made with a landscaper for use of the dried sludge and, when necessary, wet sludge is transported to the landfill site. At Richmond Municipal Sanitary District sludge is initially concentrated by dissolved air flotation and thickening. This sludge is then treated by digestion, elutriation, and vacuum filtration. Landfilling of the treated sludge is carried out at the West Contra Costa County disposal site in Richmond.

MARIN COUNTY

Central Marin Subregional Area

The Central Marin Subregion is composed of Sanitary District No. 1, San Rafael Sanitation District, and San Quentin treatment plant. At Sanitary District No. 1 centrifuged sludge is delivered to a local landscaper while San Quentin uses the sludge dried on sand beds on turf areas located on the prison grounds. At the main plant of the San Rafael Sanitation District sludge is treated by thickening, digestion, centrifugation and drying on sand beds. Prior to October 1974 sludge removed from the centrifuge and the drying beds was stockpiled and used for landscaping. Currently, however, the sludge is hauled daily to the West Contra Costa County disposal site in Richmond.

North Marin-South Sonoma Subregional Area

At Hamilton Air Force Base digested and air dried sludge is used both for landfilling and soil conditioning on the Base grounds. At the Las Gallinas Valley Sanitary District centrifuged sludge is stockpiled and is eventually used by the County Parks and Recreation Department for soil conditioning. Marin County Sanitary District No. 6 is composed of the Novato, Ignacio and Bahia service areas. Sludge treatment processes in this area include thickening, digestion, centrifugation, air drying, and lagooning. The digested sludge cake is hauled to adjacent pastures south and west of the Navato treatment plant and north of the Ignacio treatment plant. At Marin Bay plant of the San Rafael Sanitation District an aerobically digested sludge is discharged to drying beds and the dried sludge is used as a soil conditioner in city parks and grounds.

Southern Marin Subregional Area

Sludge from the Marin County Sanitary District No. 5 is digested and vacuum filtered. Once per month local residents can pick up sludge and use it for soil conditioning. In addition to digestion, the City of Mill Valley treatment plant utilizes centrifugation and drying beds. Landfilling of the sludge is accomplished on treatment plant grounds and some of the sludge is used for soil conditioning. At Richardson Bay Sanitary District treatment plant sludge is incinerated and the wet ash is discharged to sedimentation ponds. These ponds are cleaned every five years and the residue is disposed of by landfilling on the surrounding land. At Sausalito-Marin City treatment plant a vacuum filter was recently installed for sludge dewatering purposes. The County of Marin applies the sludge generated at this plant to park lands for soil conditioning purposes.

NAPA COUNTY

Napa-Vallejo Subregional Area

At Napa Sanitary District sludge is disposed of by on-site land disposal and by disbursement to local residents for soil conditioning. In addition to digestion, drying beds, and lagoons there is periodic use of a centrifuge at the treatment plant. American Canyon Water District has a self-sustaining lagoon system which disposes of the sewage sludge by decomposition processes.

Upper Napa Valley Subregional Area

The City of St. Helena also uses self sustaining sludge lagoons and has no need for other sludge disposal facilities at present time. Sludge treatment at the City of Calistoga consists of digestion, air drying, and lagooning. Chemical as well as organic sludge are generated at this plant which are disposed of by spreading and discing on land adjacent to the treatment plant. Sludge treatment in Yountville is accomplished by use of digestion tanks and air drying beds. This sludge is disposed to land in the immediate Yountville area.

SAN FRANCISCO COUNTY

San Francisco County Subregional Area

The San Francisco subregional area contains the North Point, Southeast and Richmond Sunset treatment plants. Sludge from the North Point plant is treated at the Southeast treatment plant which uses thickening, digestion, and vacuum filtration. Treated sludge from the Southeast plant is hauled by trucks to the Mt. View sanitary landfill for final disposal. At Richmond Sunset treatment plant sludge is treated in a similar fashion but the treated sludge is used for soil conditioning in the Golden Gate Park area.

SAN MATEO COUNTY

San Mateo County Subregional Area

Wastewater systems in San Mateo County are normally considered within two separate areas, those on the bayside and the smaller coastal districts. The bayside areas are subdivided into three planning units; the northern, central, and southern bayside units.

The communities of South San Francisco, San Bruno, Millbrae, Burlingame, and the San Francisco International Airport comprise the northern bayside planning unit. Centrifuged sludge from the South San Francisco-San Bruno treatment plant is composted and sold by a sludge contractor as a soil conditioner. At the San Francisco International Airport treatment plant sludge is treated by digestion and vacuum filtration. This sludge is then used as landfill on lands surrounding the airport. The City of Millbrae treatment plant produces a digested and centrifuged sludge which is hauled to a sanitary fill site in Menlo Park. Sludge from Burlingame treatment plant is also transported to the same sanitary landfill site. At the Burlingame treatment plant sludge undergoes gravity dewatering, thickening, wet oxidation, digestion and drying on sand beds prior to final disposal.

The central San Mateo County planning unit includes San Mateo and Foster City. At the City of San Mateo's treatment plant centrifuged sludge is incinerated and the residue from incineration is disposed of at the City refuse disposal site. Foster City also has incineration facilities but they are not in use at the present time. In the interim period raw sludge is centrifuged and hauled to the San Jose sanitary landfill.

Belmont, San Carlos, Redwood City and Menlo Park comprise the southern bayside unit. At Belmont San Carlos treatment plant digested sludge is centrifuged and is disposed of in the South County sanitary landfill in Menlo Park. Similar methods of sludge treatment and disposal are employed at Redwood City and Menlo Park Sanitary District treatment plants.

Municipal dischargers located on the coastal side of San Mateo County consist of North San Mateo County Sanitation District, Pacifica, Montara Sanitary District, Granada Sanitary District and Half Moon Bay. North San Mateo County Sanitation District uses gravity dewatering and thickening prior to digestion of the sewage sludge. Disposal is carried out by hauling the centrifuged sludge to local parks, cemetaries, golf courses, and to San Mateo City landfill site. At Pacifica treatment plant digested and centrifuged sludge is hauled to the South County sanitary landfill in Menlo Park. At Montara and Granada Sanitary Districts and the City of Half Moon Bay treatment plants wastewater sludge is treated by digestion and centrifugation. After air drying the sludge is stockpiled and used by local residents for soil conditioning.

SANTA CLARA COUNTY

South San Francisco Bay Subregional Area

The City of Palo Alto treatment plant also treats wastewater flows generated in Los Altos and Mt. View areas. After centrifugation and dewatering, the raw sludge is incinerated and the residue is hauled daily to the Palo Alto refuse disposal site for final disposal. Sludge treatment at the San Jose-Santa Clara treatment plant includes dissolved air flotation, digestion and discharge to lagoons. A portion of the total production is removed from storage by drag line and is ultimately marketed commercially. The City of Sunnyvale disposes of digested sludge in lagoons where organic material is converted to cellular matter. No significant sludge buildup has yet occured in these lagoons. At Gilroy-Morgan Hill treatment plant digested sludge is discharged to drying beds. Upon drying the sludge is stockpiled and is made available to local residents for use as a soil conditioner.

SOLANO COUNTY

Benicia Subregional Area

During the summer digested sludge from the Benicia treatment plant is discharged to drying beds. When dry, the sludge is used by the City Parks Department for soil conditioning. In the winter treated sludge is stored in holding ponds for dewatering and reuse during the summer.

Fairfield-Suisun Subregional Area

At Cordelia treatment plant raw sludge is allowed to recirculate to the aeration basin with subsequent discharge to drying beds. Sludge is disposedof by landfilling or as a soil conditioner. At Travis Air Force Base digested sludge is disposed on land adjacent to the treatment plant. At Fairfield-Sisun Sewer District, after thickening and centrifugation, the sludge is incinerated. Disposal of the ash is carried out by landfilling at the treatment plant site.

Napa-Vallejo Subregional Area

Mare Island has a primary treatment plant in which sludge is digested and is discharged to drying beds. Due to the small quantities of sludge involved these beds have sufficient storage capacity for present sludge beds. At Vallejo Sanitation and Flood Control District digested and dewatered sludge is disposed in a local landfill. At the Vaccaville treatment plant digested sludge is discharged to lagoons for storage and evaporation purposes. The remaining capacity of lagoons at this plant is estimated at 7 to 8 years. The City of Dixon utilizes oxidation ponds for sewage treatment and no sludge has yet been removed from these oxidation ponds.

SONOMA COUNTY

South Sonoma Subregional Area

The City of Petaluma utilizes sludge digestion and centrifugation processes. The sludge is then disposed of in the City landfill located to the south of the treatment plant. Lagoons and soil conditioning are both methods of sludge disposal used by Sonoma Valley County Sanitation District. This sludge is anaerobically digested prior to discharge to the lagoons.

North Sonoma Subregional Area

The City of Santa Rosa's Laguna treatment plant is a secondary plant which discharges aerobically digested sludge to land adjacent to the plant. Periodically, the dried sludge is disced into the soil. West College Avenue treatment plant is also a City operated plant which discharges digested sludge to lagoons. The Oakmont treatment plant is also a City operated plant which disposes of sludge by discing into the soil. After a lagoon is filled the solids are allowed to dry. These solids are then removed and are used as a soil conditioner by the City and local residents. Presently the Rohnert Park-Cotati treatment plant has sufficient capacity in their drying beds for disposal of their digested sludge. Sludge in the Sebastopol treatment plant is treated by anaerobic digestion and is discharged to holding ponds. Windsor County Water District, however, allows the dried sludge to be used by local residents for soil conditioning.

OPERATING COSTS OF EXISTING TREATMENT AND DISPOSAL FACILITIES

Data on annual operating costs of existing wastewater solids treatment and disposal facilities were obtained from questionaires circulated by BASSA and are summarized in Table IV-2. This information was provided for treatment, storage, disposal and reuse categories. However data is not available for all wastewater management agencies in the area. Reported data in Table IV-2 show that a total annual operation and maintenance cost of $3,200,000 was incurred during 1974 calendar year. This cost is associated with a total average dry weather flow of 377 mgd. Therefore extrapolation of this cost for the reported 1974 total flow of 533 mgd would yield a total annual operation and maintenance cost of $4,500,000 for existing wastewater solids management systems in San Francisco Bay Area.

From data presented in Table IV-2 it can also be observed that more than 64 percent of the reported annual cost is incurred for wastewater solids treatment facilities whereas the combined cost of transportation and disposal operations constituted about 19 percent of the total cost. Reuse operations received the least expenditure of funds compared to other categories of activity reported in Table IV-2.

Table IV-2. Reported 1974 Annual Operation and Maintenance Costs for Wastewater Solids Management Systems in San Francisco Bay Area

Sewerage Agency	Treatment	Storage	Transportation	Disposal	Reuse	Total
Alameda County						
Alameda Creek Subregion						
Livermore	60,000	10,000	20,000	0	10,000	100,000
Pleasanton	1,082	0	2,418	0	0	3,500
Valley Community Services District	N/A	N/A	N/A	N/A	N/A	N/A
East Bay Subregion						
EBMUD	320,397	0	52,095	22,584	0	395,076
City of Hayward	6,000	0	1,000	5,000	0	12,000
Oro Lomo Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
City of San Leandro	N/A	0	6,000	24,000	0	30,000
Union Sanitary District	84,859	38,000	0	0	0	122,859
Alvarado Plant						
Newark Plant						
Irvington Plant						
Contra Costa County						
City of Antioch	N/A	N/A	N/A	N/A	N/A	N/A
City of Brentwood	5,000	0	0	2,000	1,000	8,000
CCCSD	30,000	0	0	0	0	30,000
City of Concord	N/A	N/A	N/A	N/A	N/A	N/A
Crockett-Valona	N/A	N/A	N/A	N/A	N/A	N/A
Mountain View SD	10,000	0	10,000	0	0	20,000
City of Pinole	N/A	0	2,946	1,167	0	4,113
Oakley	N/A	N/A	N/A	N/A	N/A	N/A
Bethel Island	N/A	N/A	N/A	N/A	N/A	N/A
Byron Discovery Bay	N/A	N/A	N/A	N/A	N/A	N/A
City of Pittsburg						
Camp Stoneman Plant	N/A	N/A	N/A	N/A	N/A	192,231
Montezuma Plant	N/A	N/A	N/A	N/A	N/A	
Richmond Municipal Sanitary District	11,400	0	9,600	7,000	0	28,000
Rodeo Sanitary District	N/A	N/A	N/A	N/A	N/A	300
San Pablo Sanitation District	14,000	0	36,000	0	0	50,000
CCCSD 7A	N/A	N/A	N/A	N/A	N/A	N/A
Marin County						
Central Marin Subregion						
Sanitary District No. 1	N/A	N/A	N/A	N/A	N/A	N/A
San Quentin Prison	N/A	N/A	N/A	N/A	N/A	N/A
San Rafael Sanitary District	23,077	28,847	11,538	1,154	6,000	70,616
North Marin - South Sonoma Subregion						
Hamilton Air Force Base	N/A	N/A	N/A	N/A	N/A	N/A
Las Gallinas Valley Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
Marin County Sanitary District No. 6	17,092	727	727	727	727	20,000
San Rafael Sanitation District No. 12	36	0	0	110	183	329
Southern Marin Subregion						
Marin County Sanitary District No. 5	1,382	0	516	0	0	1,898
City of Mill Valley	N/A	N/A	N/A	N/A	N/A	N/A
Richardson Bay Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
Sausalito - Marin City	N/A	N/A	N/A	N/A	N/A	N/A

Table IV-2. Reported 1974 Annual Operation and Maintenance Costs for Wastewater Solids Management Systems in San Francisco Bay Area

Sewerage Agency	Treatment	Storage	Transportation	Disposal	Reuse	Total
Napa County						
Napa-Vallejo Subregion						
Napa Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
Upper Napa Valley Subregion						
City of Calistoga	37	0	0	438	0	475
City of St. Helena	N/A	N/A	N/A	N/A	N/A	N/A
City of Yountville	N/A	N/A	N/A	N/A	N/A	N/A
City and County of San Francisco						
North Point Plant Southeast Plant Richmond Sunset Plant	1,173,622	0	446,378	Included in transportation cost	N/A	1,620,000
San Mateo County						
South San Francisco - San Bruno	N/A	N/A	N/A	N/A	N/A	79,316
San Francisco Airport	N/A	N/A	N/A	N/A	N/A	N/A
City of Millbrae	10,600	0	14,400	Include in the preceding cost item	0	25,000
City of Burlingame	N/A	N/A	N/A	N/A	N/A	N/A
City of San Mateo	N/A	N/A	N/A	N/A	N/A	N/A
Foster City	N/A	N/A	N/A	N/A	N/A	N/A
Belmont - San Carlos	16,250	0	4,375	4,375	0	25,000
Redwood City	11,470	0	5,890	3,100	0	20,460
Menlo Park Sanitary District	3,318	4,741	310	3,905	0	12,274
North San Mateo County Sanitation District	N/A	N/A	N/A	N/A	N/A	N/A
City of Pacifica	N/A	N/A	N/A	N/A	N/A	N/A
Montara Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
Granada Sanitary District	5,000	500	0	0	0	5,500
City of Half Moon Bay	N/A	0	0	300	0	300
Santa Clara County						
South San Francisco Bay Subregion						
City of Palo Alto	N/A	N/A	N/A	N/A	N/A	N/A
San Jose - Santa Clara	190,000	10,000	0	0	0	200,000
City of Sunnyvale	N/A	2,500	0	0	0	2,500
Gilroy - Morgan Hill	N/A	N/A	N/A	N/A	N/A	N/A
Solano County						
Benicia Subregion						
City of Benicia	3,000	0	1,000	1,000	0	5,000
Fairfield-Suisun Subregion						
Cordelia	N/A	N/A	N/A	N/A	N/A	N/A
Fairfield-Suisun Sanitary District[1]	N/A	N/A	N/A	75,000	N/A	75,000
Travis Air Force Base	N/A	N/A	N/A	N/A	N/A	N/A
Napa-Vallejo Subregion						
Mare Island	N/A	N/A	N/A	N/A	N/A	N/A
Vallejo Sanitary District and FCD	N/A	N/A	N/A	N/A	N/A	N/A
Vacaville	N/A	N/A	N/A	N/A	N/A	N/A
Dixon	N/A	N/A	N/A	N/A	N/A	N/A
Sonoma County						
North Marin - South Sonoma Subregion, Sonoma County						
City of Petaluma	36,000	12,000	6,000	6,000	0	60,000
Sonoma Valley County Sanitary District	N/A	N/A	N/A	N/A	N/A	N/A
North Sonoma Subregion						
City of Santa Rosa	N/A	N/A	N/A	N/A	N/A	N/A
Laguna Plant	N/A	N/A	N/A	N/A	N/A	N/A
West College Plant	N/A	N/A	N/A	N/A	N/A	N/A
Oakmont	N/A	N/A	N/A	N/A	N/A	N/A
Rohnert Park-Cotati	N/A	N/A	N/A	N/A	N/A	N/A
City of Sebastopol	N/A	N/A	N/A	N/A	N/A	N/A
Windsor Co. Water Dist.	N/A	N/A	N/A	N/A	N/A	N/A
Totals	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]

CHAPTER V

EXISTING AND PROJECTED MUNICIPAL SLUDGE LOADINGS

Data on existing municipal wastewater sludge loadings were developed on the basis of information contained in BASSA questionaires as well as discussions held with individual municipal dischargers in the study area. These data are presented in detail in Table IV-1. A summary of existing raw sludge loadings are repeated in Table V-1 for comparison with projected sludge loadings in the study area. Both existing and projected 1985 and 2000 municipal sludge loading data are presented in Table V-1 for future treatment plant arrangements recommended in the Water Quality Management Plan for the San Francisco Bay Basin.

From data presented in Table V-1 it can be observed that raw wastewater solids loadings are expected to increase from the 1974 level of 11,700 tons per day to 19,000 tons per day in 1985 and 24,200 tons per day in year 2000. The values reported in this table are only for general purposes, in keeping with the scope of this study, and not intended to be detailed estimates. The projections are the result of several assumptions which could affect the totals as reported. However, those assumptions, which are discussed at length below, were used to provide an overview assessment of the magnitude of the regional situation in the future, and are not significant in regard to conclusions reached in this report.

Projected wastewater flows presented in the draft of the Basin Plan were developed on the basis of the Department of Finance E-O projections for counties designated as critical air basin areas whereas D-150 projections were used for other counties in the San Francisco Bay Area. The critical air basin encompasses the counties of Alameda, San Francisco, San Mateo, Santa Clara and Contra Costa in the San Francisco Bay Area. However, reported 1974 wastewater flows in many areas were higher than 1974 flows which can be obtained by interpolation between 1970 and 1980 wastewater flows presented in the Basin Plan report. For purposes of this study, projected 1985 and 2000 wastewater flows in the affected areas were increased by the difference between reported and calculated 1974 flows. The increment to projected 1985 and 2000 flows for various affected dischargers are shown below:

Discharger	Flow Increment, mgd
City of Hayward	4
City of San Leandro	2.1
Richmond MSD	2.4
City of San Francisco	10.4
Combined System for cities of San Carlos, Belmont, Redwood City and Menlo Park	3.4
City of Pacifica	1.1
City of Benicia	0.5

Table V-1. Existing and Projected Municipal Sludge Loadings in San Francisco Bay Area

Sewerage Agency	1974[a] ADWF, mgd	1974[a] Raw Sludge[b], tons/day	1985 ADWF, mgd	1985 Raw Sludge[b], tons/day	2000 ADWF, mgd	2000 Raw Sludge[b], tons/day
Alameda County						
Livermore	4.3	102	6.1	178.4	8.6	251.6
Valley Community Services District	4.95	126	9.8	286.7	15.9	465.1
EBMUD	85	1,220	98	2,779	105	3,071
City of Hayward	12.5	315	14.5	424.1	16.8	491.4
Oro Loma Sanitary Dist.	13	425	14.4	421.2	17.6	514.8
City of San Leandro	7.5	213	8.6	251.6	10.0	292.5
Union Sanitary District Alvarado Plant	15.44	345	19.6	573.3	24.1	707.9
Subtotal	142.69	2,746	168	4,914.3	198	5,794.3
Contra Costa County						
City of Brentwood	0.45	5.6	1.0	29.3	2.0	58.5
CCCSD	30.5	437.2	34.8	1,017.9	43.5	1,272.4
Pittsburg-Antioch	4.98	50.8	6.2	181.4	8.6	251.6
San Pablo Sanitary Dist.	8.35	243.5	10.4	304.2	12.9	377.3
Richmond Municipal Sanitary District	8.0	255	8.9	260.3	9.7	283.7
CCCSD No. 19	.15	4.4	.22	6.4	.31	9.1
CCCSD No. 15	.14	4.1	.19	5.5	.27	7.9
Subtotal	52.57	1,000.6	61.71	1,805	77.28	2,260.5
Marin County						
Sanitary District No. 1	12.20	166.0	14.7	430.0	18.1	529.4
Hamilton AFB	5.8	139.7	8.0	234.0	12.0	351.0
Subtotal	18.00	305.7	22.7	664.0	30.1	880.4
Napa County						
City of Calistoga	.35	4.4	.71	20.8	1.54	45.0
Napa Sanitary Dist.	5.0	62.5	8.8	257.4	14.8	432.9
City of Yountville	.12	1.9	.25	7.3	.53	15.5
City of St. Helena	0.30	8.8	0.35	10.2	0.40	11.7
Subtotal	5.47	77.6	10.11	295.7	17.27	505.1
City and County of San Francisco						
Southeast Plant	86	1,628	89.2	2,609.1	97.5	2,851.9
Richmond Sunset Plant	20	272.7	22.0	643.5	25.0	731.3
Subtotal	106	1,900.7	111.2	3,252.6	122.5	3,583.2

Table V-1. Existing and Projected Municipal Sludge Loadings in San Francisco Bay Area (Cont'd)

Sewerage Agency	1974[a]		1985		2000	
	Flow, mgd	Raw Sludge[b], tons/day	Flow, mgd	Raw Sludge[b], tons/day	Flow, mgd	Raw Sludge[b], tons/day
San Mateo County						
SSF/Airport/San Bruno	9.33	262.6	10.3	301.3	10.5	307
City of Millbrae	2.3	67.3	2.4	70.2	2.4	70.2
City of Burlingame	4.2	110	4.5	131.6	4.6	134.6
City of San Mateo	12.5	148	16.0	468.0	17.6	514.8
Redwood Shores	18.7	294.5	22.0	643.5	25.0	731.3
North San Mateo Co.	6.0	60.1	6.5	190.1	7.6	222.3
City of Pacifica	3.5	68	4.5	131.6	5.6	163.8
City of Half Moon Bay	.88	17	1.1	32.2	.9	26.3
Subtotal	57.41	1,027.5	67.3	1,968.5	74.2	2,170.3
Santa Clara County						
City of Palo Alto	25	731.3	29.6	865.8	35.1	1,026.7
San Jose - Santa Clara	80	3,013	95.2	2,784.6	134.4	3,931.2
City of Sunnyvale	16.5	206	17.4	509.0	20.6	602.6
Gilroy - Morgan Hill	3.1	38.6	8.2	239.9	17.7	517.7
Subtotal	124.6	3,988.9	150.4	4,399.3	207.8	6,078.2
Solano County						
City of Benicia	1.2	15	1.7	49.7	3.5	102.4
Fairfield-Suisun Sanitary District	6.1	77.2	12.0	351.0	22.2	649.4
Vallejo Sanitary Dist. and FCD	8.1	84.1	9.9	289.6	13.0	380.3
Vacaville & Dixon	4.95	134.5	11.5	336.3	14.9	435.7
Subtotal	20.35	310.8	35.1	1,026.6	53.6	1,567.8
Sonoma County						
City of Petaluma	3.5	75	5.2	152.1	8.8	257.4
Sonoma Valley County Sanitary Dist.	1.8	58.4	3.2	93.6	5.8	169.7
City of Santa Rosa Laguna Plant	4.0	85.4	12	352.1	27.53	805.3
West College Plant	6.5	101.9	6.5	190.1	6.50	190.1
Oakmont	0.16	1.8	.31	9.0	.56	16.5
Healdsburg	0.5	14.6	0.59	17.25	0.68	19.9
Windsor County Water Dist.	0.3	3.8	1.42	41.4	2.72	79.6
Subtotal	16.76	340.9	29.25	855.55	52.59	1,538.5
Grand Total	548.85	11,698.7	655.77	19,181.55	833.34	24,378.3

[a]Based on reported data for existing sludge management system
[b]96-percent moisture content

Adjustment to wastewater flows reported in the Basin Plan were also made to take account of the nondiscrete industrial entities discharging wastewater into municipal sewerage systems. Based on these adjustments, projected 1985 and 2000 wastewater flows for the combined system of South San Francisco, San Francisco Internation Airport and San Bruno were raised by 1.5 mgd and 1.3 mgd, respectively. Corresponding adjustments for the City of Millbrae were 0.1 mgd and 0.2 mgd, respectively, and the projected 1985 and 2000 flows for the City of Burlingame were raised by 0.9 mgd.

Only raw sludge loadings are presented in Table V-1 because various dischargers will employ different methods of sludge treatment in the study area. A unit loading of 29.25 tons of raw sludge per million gallons of secondary treated wastewater was assumed in developing 1985 and 2000 loadings presented in Table V-1.

The unit raw sludge loading of 29.25 tons per million gallons of sewage is an average value for secondary activated sludge level of treatment reported in the literature.[23] This value is consistent with existing unit loading data reported by many of the dischargers. However wide variations are observed in the reported 1974 unit loadings. These variations can in part be attributed to lack of accurate records on the amount of sludge removed from wastewater streams at various treatment plants. Also design and operation differences contribute to this variation.

Although advanced levels of treatment have been specified in the Basin Plan for some dischargers, for purposes of projecting future volumes of sludge it was assumed that all dischargers would have only secondary treatment by 1985.

This assumption does not significantly affect the total reported amounts because the major dischargers are only required to provide secondary level of treatment for their discharges.

Two anomalies in Table V-1 need to be addressed. First, the small discrepancy between total 1974 raw sludge loading presented in Table V-1 and that presented in Table IV-1 is caused by the fact that a loading of 29.25 tons of raw sludge per million gallons of sewage was assigned to all plants for which no sludge loading is reported in Table IV-1. This was done to enable a better comparison between 1974, 1985 and year 2000 raw sludge loadings.

Reduction in sludge loading from 1974 to 1985 for San Jose-Santa Clara treatment facility is probably due to errors in estimating the existing sludge loading. Data on existing sludge loadings were obtained from the wastewater agencies and no attempt was made to modify the magnitude of these reported loadings.

From the above discussion it can be seen that more precise wastewater solids loading data corresponding to stipulated levels of treatment for individual dischargers should be developed in a comprehensive facilities planning study before detailed facility plans are proposed for implementation.

CHAPTER VI

SOLIDS PROCESSING SYSTEMS

Present regulatory criteria require stabilization of wastewater solids prior to final disposal on land. Dewatering of wastewater solids is also required when disposal is carried out by landfilling operations. While stabilization and dewatering are the major solids processing systems involved in producing solids suitable for final land disposal, successful systems must also include efficient conditioning facilities, reliable in-process storage techniques, and adequate recycled liquor treatment processes. A brief discussion is presented in this chapter on the various processes involved in stabilization, dewatering and final disposal of wastewater solids. This discussion has in the main part been excepted from reference 22.

STABILIZATION PROCESSES

Stabilization of wastewater solids for the purposes of this study is defined as the treatment required to allow the solids removed from wastewater liquid treatment processes to be disposed of on land without appreciable damage to the environment, and without creating nuisance conditions. As such, any solids treatment process which produces, as its end result, a residue which may be safely disposed either to a sanitary landfill or a land spreading site constitutes a stabilization process. When ranked in descending order on the basis of the quantity of residue produced such stabilization processes include the following:

1. Chemical Stabilization.
2. Thermal Stabilization.
3. Biological Stabilization.
4. Composting.
5. Heat Drying.
6. Pyrolysis.
7. Incineration.

Chemical Stabilization

The two most common chemical stabilization processes involve the use of lime and chlorine. Both processes have received increased attention as wastewater solids disposal has been limited to the land. Lime is a good stabilizing agent which is safe to handle and produces no dangerous by-products. The same is not true for chlorine. Energy for chemical stabilization must be supplied by outside sources because no heat or power is recoverable from within the process.

Lime treated solids are not chemically stable and in time a gradual reduction of pH may create nuisance conditions. Lime treated sludge can be safely disposed of in sanitary landfills but the sludge must be spread in thin layers and covered on a daily basis to eliminate nuisance conditions.

The chlorine stabilization process involves proprietary Purifax equipment introduced by the BIF Corporation. This equipment uses heavy doses of chlorine, about 2000 mg/l of raw sludge, to oxidize the sludge and destroy most of its biological activity. Chlorine treated solids dewater well on sand beds. However, this sludge is not chemically stable and in time can become a nuisance if stored in volume in confined spaces. Mechanical dewatering requires pH adjustment to protect equipment and improve efficiency. The low pH (2-3) of the stabilized solids along with the production of high concentrations of chloramines makes disposal of the sludge to sanitary landfills the only viable land disposal alternative. Liquid recycle from dewatering chlorine stabilized solids contains high concentrations of chloramines.

Thermal Stabilization

Thermal stabilization or pasteurization uses heat to destroy the pathogenic organisms. In Europe the Swiss and West Germans thermally stabilize wastewater solids prior to spreading it on pastures during the summer growing season. Thermal stabilization at 70°C and atmospheric pressure for 30 to 60 minutes has been found effective for destroying pathogens and pasteurizing the sludge.[24] Other thermal stabilization processes using both higher temperature and pressures on raw sludge are also in operation. High temperature (170-210°C) medium pressure (200 psi) thermal stabilization processes have been used primarily to improve sludge dewaterability. However these processes destroy all pathogenic organisms and result in 24 percent destruction of the total process solids; thereby, producing a stable residue. High temperature (170-210°C), high pressure (1000-1750 psi) thermal stabilization processes actually oxidize the solids and reduce the volatile matter content by 90 percent. These processes produce a residue which can be easily dewatered.

All forms of thermal stabilization act to solubilize and hydrolyze the hydrate solids particles making the mineral matter and left over particle debris easier to dewater, but producing a cooking liquor which is highly polluted and contains a high proportion of nonbiodegradable matter. A number of plants with thermal stabilization processes have experienced odor or treatment efficiency difficulties which are directly attributable to the liquid recycle from their solids thermal stabilization process.[25] Thermal stabilization requires great quantities of energy which, except for the high temperature, high pressure process, must be fully supplied by outside sources. Although the high pressure system can be made to self-sustain the oxidation reaction, any recovery of heat or power from the system is very expensive and unreliable.

Thermally stabilized solids have very little nutrient value and the product of low temperature low pressure processes is not chemically stable. All thermally stabilized solids are considered sufficiently stable to be acceptable for sanitary landfill disposal.

Biological Stabilization

Biological stabilization depends on microorganisms within a digestion process to perform the stabilization function. Aerobic digestion is performed in an oxygen-rich atmosphere where free molecular oxygen is available for microorganism respiration while in the anaerobic digestion process microorganisms obtain the required oxygen for their respiration by breaking down the molecules of organic matter.

Although our atmosphere contains virtually an unlimited supply of oxygen, considerable energy (.27-.34 hp/ton of raw sludge from a secondary activated sludge plant) must be expended to assure an adequate supply of oxygen to the aerobic microorganisms.[22] Under optimal conditions the highest percent of destruction of volatile suspended solids which can be expected from aerobic digestion is about 50 percent, whereas the normal range varies between 10 and 45 percent.

Anaerobic digestion usually takes place within an enclosed environment designed to maintain a complete absence of oxygen. Some energy is required (.07-.10 hp/ton of raw sludge from a secondary activated sludge plant) to maintain the proper temperature and a homogeneous mixture of active microorganisms and raw sludge feed, but this level of energy is many times less than that required to maintain aerobic conditions in an aerobic digester.[22] The enclosed environment makes it feasible to maintain the anaerobic digestion at the most efficient temperature for maximum loading (usually about 95°F) and allows for the collection of the methane gases formed during the metabolism of the anaerobic microorganisms. A well designed anaerobic digestion process will result in a 50 to 60 percent destruction of volatile suspended solids and will always produce a stabilized residue having a volatile to total suspended solids ratio of less than 60 percent. This reisude is extremely stable and relatively free of nuisance odors.

Aerobically digested solids are relatively easy to dewater and create fairly low concentrations of solids, BOD, COD, TKN and NH_4 in the liquid recycle. Anaerobic digestion, especially of wastewater solids from biological secondary treatment plants, produces solids which are difficult to dewater and create high concentrations of solids, BOD, COD, TKN and NH_4 in the liquid recycle.

Heat Drying

Dried wastewater solids can be an excellent base for a fertilizer or soil conditioner. When unstabilized sludge is heat dried it will contain significantly higher levels of nutrients. The economic cost and energy demands for such systems are extremely high, and therefore few large facilities have been built. With the increase in fertilizer prices it is entirely possible that more communities may be compelled to investigate this possible source of income. It is expected, that the present energy shortage and the high heat of vaporization requirement for water (approximately 1000 btu/pound) will probably continue to limit its acceptability. Forced heat drying is most often employed for the large treatment plants where space is extremely limited. Equipment most often used in this process includes the flash dryer, screw conveyor, multiple hearth, rotary, and atomized spray towers. Two recent additions to this list include the Boeing Best

system and a jet mill dryer classifier. The BEST system uses a special solvent solution to solubilize the entire raw wastewater solids production at room temperature (20°C) and then extracts all the solvent back out from the recycle liquor at 68°C temperature. The solids are centrifuged from the solubilized solids while the solvent is at its miscible temperature (20°C). Dewatered solids are then oven dried at 250°F for about 30 minutes to assure complete recovery. The use of the solvent is claimed to save about 65-70 percent of the energy required to dry the solids. The BEST system is currently being tested in Seattle. It is still too early to tell whether or not this solvent extraction process will be able to save the energy indicated by early laboratory scale tests. The jet mill drying system is somewhat similar to the flash dryer except that the dryer, which operates at 100°F, is a toroidal shaped unit which has no moving parts and has the ability to dry and classify soldis simultaneously. A full size unit is presently being operated at the Blue Plains plant in Washington, D.C. by a private contractor. Operational data on the effictiveness of this system is not yet available.

Heat drying systems operate at temperatures well above the 70°C pasteurization level for periods exceeding 30 minutes, therefore, all pathogens are destroyed during this process. All heat drying processes include a mechanical dewatering step prior to the final heat drying to reduce the water which must be vaporized. Recycled liquor from these processes is limited to the liquids removed during this dewatering step.

Pyrolysis

Although pyrolysis is a controlled combustion system, it does not involve oxidation processes, because in a pyrolysis system the waste solids are not burned. The pyrolysis process requires heating of the fuel or solids to a temperature at which the volatile matter distills, leaving carbon and inert material behind. These materials do not burn because the heating takes place in an atmosphere deficient of oxygen. The volatile matter off-gas may be burned as waste in a secondary chamber to which air is added, or the off-gas may be cooled and condensed to recover oil and tars or cleaned and used as a fuel. Like oxidizing systems, pyrolysis minimizes residue volume and sterilizes the end product. Unlike oxidizing systems, however, it has the potential of eliminating air pollution and producing useful by-products. Air pollution is controlled because heating takes place in a closed system without oxygen.

Much interest has been shown in pyrolysis for the combined combustion of garbage and wastewater solids. The Metropolitan Sewer Board of the Twin Cities area of Saint Paul and Minneapolis, Minnesota are planning a pyrolysis system for their 230 mgd Metropolitan Wastewater Treatment Plant. They plan to mix their dewatered sludge cake with shredded combustible refuse. In Orange County, California, the process is being used in a pilot facility on wastewater solid alone to provide activated carbon to treat and purify the incoming wastewater stream, while in Seattle they are studying the possibilities of using community solid waste to manufacture methanol as a fuel.

Pyrolysis involves the conservation of resources and is, therefore, potentially a very attractive alternative for the disposal of wastewater solids in the San Francisco Bay Area. Unfortunately, to date, no cost, energy or

reliability data is available to assess the capabilities of a full-scale operating plant. Pyrolysis has been used for years by industry to produce charcoal and methanol from wood, and in coal gasification. However, as many designers and manufacturers have found out the hard way, wastewater solids material handling can be very different from industrial material handling.

Incineration

Incineration is the ultimate in stabilization processes. The complete combustion (oxidation) of the organic wastewater soldis at temperatures exceeding 1400°F completely sterilizes and minimizes the volume of the remaining residue. The high heat of vaporization of water necessitates the expenditure of considerable supplemental fuel for the initial drying step. To reduce this supplemental fuel requirement, solids are always mechanically dewatered to as low a moisture content as possible (70 to 80 percent) prior to incineration. Incineration supplemental fuel requirements, when stabilizing raw solids, will range between 5,000 - 10,000 btu per pound of dry solids of feed.

After dewatering, the incineration, drying and combusion process consists of the following phases: (1) raising the temperature of the feed solids to 212°F, (2) evaporating water from the solids, (3) increasing the water vapor and air temperature of the gas, and (4) increasing the temperature of the dried solids volatiles to the ignition point. These drying and combustion phases may be practiced in separate pieces of equipment as with flash-drying units or successively in the same unit like multiple hearth furnaces. Manufacturers have developed a variety of sludge drying and combusion equipment. These include, in addition to those previously mentioned, traveling-grate furnaces, rotary-kiln type furnaces, fluidized-bed units and atmozied spray units. Cyclonic reactors and infrared electric furnaces have been developed for small plants and a special Water-Grate incinerator for the exclusive combustion of highly volatile scum has been developed by Nichols Engineering and Research Corporation. The most popular wastewater solids incinerators are the multiple hearth and fluidized-bed units.

DEWATERING PROCESSES

Compliance with regulations adopted by the State Water Resources Control Board[25] for waste disposal to land would in most circumstances require dewatering of stabilized wastewater solids. When dewatering is required as part of the stabilization process, such as with heat drying, incineration or pyrolysis, the amount of moisture remaining becomes much more important. The high heat of vaporization of water (approximately 1000 btu per pound) makes each extra pound of water in the dewatered cake feed critical to the efficient operation of the system. The dewatering processes commonly used in sludge treatment operations are as follows:

1. Drying Beds and Lagoons.

2. Filtration.

3. Centrifugation.

Drying Beds and Lagoons

Drying beds and lagoons have historically been the first selection for the dewatering of wastewater solids. Where climatological conditions are favorable these facilities will be low in initial cost and can operate quite reliably. Drying beds require large areas of land (2 - 3 square feet per capita equivalent) and can create odor problems when they are called upon to dewater partially stabilized solids. Harvesting the dried sludge (20-50 percent moisture) can be an expensive process if it has to be carried out over limited periods of time. Land availability and costs usually limit the use of sand drying beds to small isolated hamlets. Drying lagoons have much of the same problems as drying beds. Dewatered solids removal can be more difficult than removal from drying beds because the lagooned solids contain higher moisture levels (60-70 percent). Area requirements for drying lagoons are about 1 - 2 square feet per capita equivalent.

Filtration

Vacuum and pressure filters are probably the oldest mechanical methods of dewatering in continuous use in the treatment of wastewater solids. Vacuum units have been in use 50 years and filter press units have been in use over a longer period. However operational difficulties are still encountered with these dewatering systems. A discussion on some of the filtration methods is presented below.

Rotary Vacuum Filters. A rotary vacuum filter consists of a radially sectionalized, cylindrical drum covered with a filter media. The drum rotates partially submerged in a vat of wastewater solids where its vacuum backed filter media picks up solids to form a cake. The cake is dewatered by the continuing vacuum as it rotates from the vat to its high point of rotation. At the high point of rotation, the vacuum is released and the cake allowed to rotate under gravity to its point of discharge where it is positively separated from the filter media. After releasing the cake, the media is washed before returning to the vat for pick up of more solids. The process is affected by the filterability quality of the wastewater solids which is often quite variable; therefore, each unit must be monitored continuously to assure peak efficiency. Rotary vacuum filter cake moisture content will usually range between 70-85 percent. Solids capture will average between 85-95 percent however preconditioning may be required for this system.

Pressure Filtration. Pressure filtration involves the separation of the wastewater solids from its liquor by using positive pressure to force the liquor through a filter medium. Pressure filtration is the oldest method of filtration. The porous media of a filter press is in the form of leaf filters which are normally sequentially and automatically precoated, gathered, loaded, pressurized and spread for discharge. Filter presses normally operate on a cyclic basis and, depending on the success of precoating, require frequent shutdowns for media cleaning or complete removal of the cake.

Filter press cake will usually contain only 45-55 percent moisture and have a solids recovery rate of 98 to 99 percent.

Centrifugation

Although centrifugation of wastewater solids was tried many years ago, and has been employed in various industrial processes for over 50 years, actual economical full-scale operation of wastewater solids was not successful until 1960. Since then, centrifugation dewatering has become more and more popular. Centrifuges have the advantage of being compact, totally enclosed, flexible and relatively simple to operate and control.

Most successful centrifuges are of the horizontal, cylindrical-conical, solid bowl type, although there is an increasing trend toward the use of basket and disc type centrifuges for special conditions. Process efficiency is affected by both the condition of the wastewater solids and operating variables such as bowl speed, pool volume and sludge feed rate. While not as sensitive as rotary vacuum filter operation, centrifuge operation still must be monitored often to assure peak efficiency. Moisture content of the dewatered cake varies between 70-85 percent. Low speed centrifuges have been recently introduced in this country. These centrifuges have as high as 95 percent recovery and require less energy than equivalent high speed centrifuges.

TRANSPORTATION METHODS

Selection of a sludge transport method is dictated by the nature of sludge disposal or reuse method selected as well as the final disposal or reuse site location. The environmental impact of the various transport methods will also enter into the decision making process for selection of a suitable transport method. Transport options considered in this section include pipeline conveyance, trucking on local roads, rail haul, and barging. The state of the sludge, whether in liquid or dewatered form, and transport distances are major factors affecting the feasibility of each transport method. All four potential methods of sludge transport are available in the San Francisco Bay Area. However, selection of a method of transport will depend on specific conditions of various subregional areas as well as the method of sludge disposal or reuse employed in each area. Cost data for various sludge transport alternatives in the Seattle area in Washington is presented in Fig. VI-1. From this data it can be observed that barging is the cheapest method of sludge transport for haul distances varying from 10 to 200 miles. Trucking is the next most economical method of transport over the same haul distance whereas the cost of pipeline and rail transport vary relative to each other depending on the haul distance involved. This cost data is valid for Seattle area and corresponding levels for San Francisco Bay Area could be obtained by using a factor of 1.02 which is the ratio of the Cost of Living Index for these areas over the 1974 Calendar Year.

Piping may have a significant impact on the environment during the construction stage. However once the pipeline is constructed this method of transport will pose little or no additional detrimental environmental effects. Pipeline transport is very reliable and has low operation and maintenance requirements however it lacks flexibility and poses significant institutional constraints in terms of acquiring the required rights of way. Energy consumption for pipeline transport depends on the type of terrain and direction of liquid flow in the pipe and can vary from zero to significant quantities of energy per unit of flow.

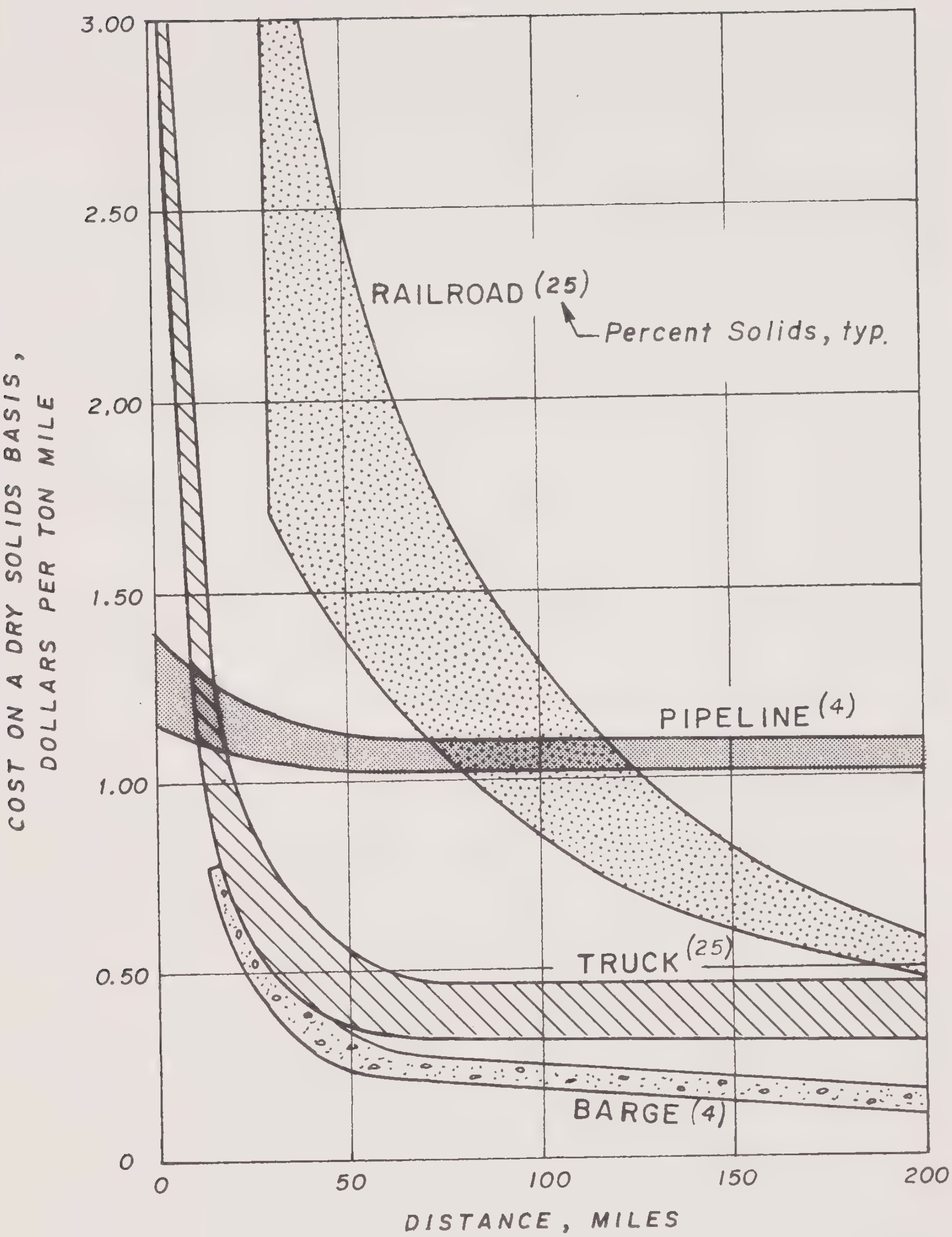


Fig. VI-1. Cost Data for Four Transportation Alternatives in Seattle, Washington (Amortization of capital over 10 years at 7 percent)

Source: From working draft of a sludge management report under preparation by Brown and Caldwell for Seattle Metropolitan Wastewater Management Authority

Truck transport allows great flexibility in shipment of wastewater solids. However this method poses serious air and noise pollution hazards and has large operation and maintenance requirements. Reliability of this method is also reduced due to the potential for strikes, energy and material shortages. Railroad transport is also of low flexibility and reliability but this method poses less air pollution hazards than truck transport. Barge transport can be utilized where navigable waters are within easy access. This method of transport is of low flexibility and the same level of reliability as truck and rail transport. A potential for water pollution is also associated with barge transport in the upper reaches of the delta. A lower air pollution potential is probably associated with this method of transport than with trucking method of transport.

CHAPTER VII

CONSTRAINTS AND CRITERIA RELEVANT TO SLUDGE DISPOSAL OPERATIONS

Constraints and criteria of varying stringency are imposed by federal state and local regulatory agencies on different sludge disposal operations. Applicable constraints range from complete prohibition on sludge disposal to any water body to specification of the type of sanitary landfills that can be used for sludge disposal purposes. Comprehensive criteria have also been developed for disposal of sludge to landfills or agricultural lands or reduction of sludge by combustion processes. A summary of applicable constraints and criteria relevant to different methods of sludge disposal is presented in this chapter.

DISPOSAL OF WASTEWATER SOLIDS TO LAND

Land disposal of wastewater solids can be carried out by one of the following four methods:

1. Disposal to landfills,
2. Spreading of wastewater solids on productive agricultural lands,
3. Spreading of wastewater solids on lands not to be used for crop production purposes such as parks, forests, landscaped areas, etc., or
4. Spreading of wastewater solids on land permanently condemned for this disposal practice.

Resources recovery goals are not attainable through the use of method 1 or 4 because in one case wastewater solids are permanently buried in the ground and in the other the land is condemned for the sole purpose of wastewater solids disposal activities. In this section constraints and criteria are presented for sanitary landfilling and spreading of wastewater solids on productive agricultural lands or landscaped areas.

Sanitary Landfills

Under present conditions, sanitary landfilling is the most readily available method of final disposal of wastewater solids. Many major cities and wastewater treatment entities such as San Francisco and the East Bay Municipal Utility District are presently using this method of disposal for most of their wastewater solids. However federal, state and local regulatory agencies are all in the process of adopting new regulations and standards for application of this disposal method and it is expected that more stringent requirements will be imposed on this method of sludge disposal in the future.

Federal Policy. The latest EPA draft on "Acceptable Methods for the Utilization or Disposal of Sludges"[25] indicates that the sanitary landfill of wastewater solids containing no free moisture is an environmentally acceptable method for final disposal. The draft policy requires all wastewater solids to be stabilized prior to sanitary landfill disposal and all sanitary landfills receiving wastewater solids to be designed and operated in accordance with current EPA guidelines for land disposal of solid wastes. The EPA criteria for stabilization requires that the ratio of volatile solids to total solids be equal to or less than 0.4, which can normally be attained through anaerobic digestion.

State Regulations and Standards. Waste discharge regulations for waste disposal to land were first adopted by the State Water Resources Control Board in March, 1972.[26] These regulations were set up to govern waste disposal to land and establish statewide disposal site and waste classification systems. Three general classes of disposal sites were established. These included the Class I site, where there can be no possibility of discharge of pollutant substances to usable waters and a natural barrier must exist to assure vertical confinement; the Class II site, where artificial barriers can be used to confine both lateral and vertical movement of pollutants or where natural features provide water quality protection; and the Class III site, where no protection against movement of pollutants is required. Class I and II sites which might be inundated by 100-year floods are restricted to the type and amount of wastes that may be accepted.

Three group classification of wastes were also formulated to regulate what wastes can be discharged to the specific classes of disposal sites. All wastewater solids with the single exception of community incinerator ashes are classified as Group 2 wastes and as such, may be accepted by either Class I or II disposal sites. Community incinerator ashes are classified as Group 1 wastes. Class II-1 disposal sites may accept some Group 1 materials under special conditions. The best information available at this time indicates that ashes from wastewater solids incinerators are acceptable at Class II disposal sites not subject to 100-year flood inundation.

There is a 75 percent moisture limit on dewatered wastewater solids which are to be disposed of to a classified site. This could be extremely difficult to meet with the vacuum filtration of digested sludge.

Digested wastewater solids containing more than 50 percent moisture can not be disposed in a Class II site by mixing it with other Group 2 materials unless either artificial or natural leachate control capabilities are available at the site. However no limitations are imposed on moisture content of wastewater solids disposed in a Class I landfill site. Mixing of dewatered solids with intermediate soil cover is allowed for meeting moisture content requirements by the San Francisco Bay Area Regional Water Quality Control Board.

The Solid Waste Management and Resource Recovery Act of 1972 created a State Solid Waste Management Board and assigned it the task of establishing and maintaining a comprehensive state solid waste management and resource recovery policy. This policy is expected to set minimum standards for safe and environmentally sound methods for the handling and disposal of the increasing volume and variety of solids wastes throughout the state. In August, 1974, the Board set forth proposed minimum standards for solids waste handling and disposal. Public

hearings were completed on these proposed standards in November, 1974. State policy for Solid Waste Management and a State Solid Waste Resource Recovery Program were adopted by the State Solid Waste Management Board on December 20, 1974.[27,28]

Even though the Solid Waste Management Board has formulated minimum standards for solids waste handling, disposal, and recovery, the State Water Resources Control Board still maintains jurisdiction over land disposal of solid wastes to the extent that they may affect the quality of waters of the state.

The State Health Department is specifically authorized to regulate the disposal of hazardous wastes. Stabilized wastewater solids are not currently included in the Department's list of hazardous materials. General public health regulations pertaining to landfill disposal of solid wastes have been developed by the State Health Department and have been incorporated in the land disposal criteria promulgated by the State Water Resources Control Board and State Solid Waste Management Board.

County Plan. The State Waste Management and Resource Recovery Act of 1972 recognizes that the primary responsibility for adequate solids waste management and planning must rest with local government. The legislation, therefore, requires each county to develop a solid waste management plan. It is expected that the state policies for solid waste management and resource recovery programs including the minimum standards for solid waste handling and disposal for the protection of the public health and the air, water and land environments and the standards and guidelines for solid waste management plans will form the basis for the development of these county plans.

Solid waste planning activities are at various stages of completion in all counties around the San Francisco Bay Area. However a finalized county wide solid waste management plan has not yet been developed for any of these counties. It is expected that sanitary landfilling will be universally selected for short-term disposal of municipal solid wastes in all counties included in the study area.

This is due to the fact that development of alternative methods of solid waste management will be time consuming and will also require the commitment of substantial financial resources. The law requires that each county develop a solid waste plan consistent with state policy and submit this plan to the State Solid Waste Management Board by January 1, 1976. This plan must be approved by two third of the cities containing at least 50 percent of the population of each county. The State Solid Waste Management Board is empowered to review and approve or disapprove the submitted plans on the basis of the adopted state policy.

Utilization

Stabilized wastewater solids have been used as a soil builder and conditioner in different forms at many localities throughout the world. Although the land application method has been practiced for a long period of time only in recent years, when disposal of wastewater solids has become an environmental issue and advanced technology has significantly improved detection equipment, meaningful scientific studies have been started on the possible long-range impact of these solids on the receiving soils. The improved detection capabilities have

indicated several potential problem areas, but as yet meaningful documented studies are unavailable. Proposed standards and regulations have been developed to eliminate these potential problems, however, these criteria are in a fluid state and will undergo modifications as more scientific data is developed through the ongoing or planned research projects.

Historical Background. For most small wastewater treatment plants, solids utilization has for years meant the use of air dried wastewater solids from sand drying beds or evaporative fill and draw lagoons for city parks and surrounding agricultural lands. Many times this material is simply stockpiled and made available to the general public. Some of the major urban areas have also practiced utilization in different forms, but usually only on the basis of disposing of the solids and not necessarily with the aim of implementing a reuse program. A few examples of this type of utilization are listed in Table VII-1.

Table VII-1. Examples of Wastewater Solids Utilization[a]

City or urban area	Plant name and capacity	Type of solids	Solids process	Years in operation	Methods of utilization
San Francisco, California	Richmond-Sunset 20 mgd	Primary	Digestion vacuum filtration	>30	Dewatered sludge used directly as soil conditioner for city parks.
Milwaukee, Wisconsin	Jones Island Plant 200 mgd	Secondary (no primary)	Vacuum filtration drying	>45	Dried sludge used as base for commercial fertilizer sold throughout U.S. "Milorganite".
Houston, Texas	North and South Side Plants 150 mgd	Secondary (no primary)	Vacuum filtration drying	>20	Dried sludge used as base for commercial fertilizers sold in Florida for orange groves.
Los Angeles, California	Joint Water Pollution Control Plant 375 mgd	Primary	Digestion centrification composting	< 1	Composted material is sold to a commercial company as a base for soil conditioner.
West Hertfordshire, England	West Hertfordshire 37 mgd	Primary Secondary	Digestion	>20	Liquid digested sludge ("HyDig") distributed to agricultural lands in surrounding countryside (7000 acres).
San Diego, California	Pt. Loma 100 mgd	Primary	Digestion	>15	Reclamation of Mission Bay sandy tidelands. Liquid digested sludge mixed with dredged material to soil builder for parkland development.
Chicago, Illinois	Southeast and Calumet 1400 mgd	Primary Secondary	Digestion	< 2	Twenty-five percent of daily sludge production being used for reclamation of strip mined areas in Fulton County some 200 miles downstate for metropolitan Chicago area. Liquid digested sludge spread over 2000 acres. To be expanded to 10,000 acres.

[a]Source: Reference 22

Until very recently no hazards were perceived relevant to the effect of toxic metals contained in wastewater solids. As scientific detection capabilities have expanded, additional data has become available on these toxic metals. Results of a 1973-74 survey of 33 municipal wastewater treatment plants in United States[29] indicate that the levels of toxic metals are higher than those presently recommended for application to agricultural soils. Average concentrations of metals in digested sludge for these 33 plants are given in Table VII-2. Studies on plant uptake rates from different types of soils have also only recently gained in momentum. Therefore there is a lack of long-range information needed to evaluate the ultimate impacts of toxic metals on productive agricultural soils and on crops grown on these soils. In the absence of long-range data no definitive conclusions can be reached regarding the probable environmental impact of wastewater solids application to productive agricultural lands. However there is a strong need for accumulation of scientific data on the effect of land application of wastewater solids on soils, crops and the human food chain.

Table VII-2. Average Concentrations of Toxic Elements in Digested Sludge for 33 Municipal Wastewater Treatment Plants[a]

Element	Medium 50% value mg/kg (dry sludge basis)
Cd	33
Cu	1,230
Hg	6.6
Ni	410
Pb	380
Zn	2,780

[a]Source: Reference 29

Federal Policy. A new draft of EPA's "Acceptable Methods for the Utilization or Disposal of Sludges" has been prepared for release early in 1975. The initial draft was released in May of 1974.[30] The draft technical bulleting issued in November, 1974 reflects EPA's shift towards the development of improved technology for returning wastewater solids to the environment in an ecologically acceptable manner, putting more emphasis on source control and pretreatment for the control of toxic materials, and requiring only that the cadmium content not be greater than 1 percent of the zinc content. Based on these criteria digested sludge from EBMUD can be utilized for soil conditioning purposes.

In addition to the limiting values for toxic elements, the EPA's November, 1974 guidelines also set forth a limit on the total amount of solids which may be applied over the life of the project to a given plot of land. This limt is based on the criterion that metal additions as zinc equivalents should not exceed 10 percent of the soil's cation exchange capacity (CEC) and the soil pH should be equal to or greater than 6.5. If the solids to be added to the soil have relatively high, concentrations of copper, nickel or zinc, this limitation severaly restricts the amount of solids which may be added per acre.

The formula for determining the maximum quantity of wastewater solids that can be applied to an acre of land is as follows:

$$\text{Total wastewater solids (dry weight tons/acre)} = \frac{\text{CEC X } 32{,}600}{\text{ppm zinc} + 2 \text{ ppm copper} + 4 \text{ ppm nickel} - 200}$$

Specific guidelines are also given in the November, 1974 draft regulation regarding the survival of pathogens and specific organisms and the levels of persistent organics, such as pesticides and polychlorinated biphenols, which could be detrimental to human health. These guidelines specify that lands receiving wastewater solids could be used for growing human food crops which are consumed raw provided that 3 years or more has elapsed since the application of the last solids load. The draft also indicates that grazing animals will not be permitted on pastures fertilized with wastewater solids until the solids residue is removed from the fodder by rain or other means.

EPA policy statements recognize the limited data used in formulating the proposed regulations and state that wastewater solids not meeting these criteria may be acceptable for use in demonstration projects. When such nonconforming types of land application are proposed, however, they must include monitoring, periodic reporting and abatement procedures. The November draft, also provides limits on the maximum quantity of lead (1,000 mg/kg dry solids) and cadmium (20 mg/kg dry solids) which can be present in wastewater solids whenever there is a risk of direct ingestion by grazing cattle. Four methods of additional pathogen reduction are discussed in EPA's policy statements. They include pasteurization (30 minutes at 70°C), high pH treatment (pH greater than 12 for 3 hours), long-term storage (120 days at 40°C), and composting (temperatures above 55°C for at least 30 days).

This draft also indicates that water monitoring for ground and surface runoff contamination will be mandatory and that the land application of wastewater solids cannot result in producing permanent changes in groundwater quality exceeding EPA chemical or pesticide level standards for raw or untreated drinking water supplies. Surface water runoff from treated lands must be controlled to prevent contravention of water quality standards.

The proposed regulations require the sludge application rates to be managed to insure that all environmental requirements are met. This involves consideration of both the toxic elements previously discussed and the salt and nitrogenous substances which are always present in wastewater solids. The nitrogenous substances are quite often the limiting variable; therefore, a total nitrogen

balance, including the amount applied, plant uptake, volatilization or denitrification loss, decaying plant matter recycle and potential for groundwater migration must be estimated. The November draft states that the total amount of plant available nitrogen which could be added by wastewater solids should not exceed "twice the nitrogen requirement of the crop grown". In order to comply with these requirements solids application rates must be harmonized with the crop growing seasons.

State Standards. As of this date, the State Water Resources Control Board's Division of Water Quality has not formulated any official guideline for the utilization and disposal of wastewater solids on land, although their Grants Management Memorandum No. 4.01, dated December 28, 1973,[31] does establish criteria for the evaluation of land disposal projects. Certainly some of the rationale and need for analysis reflected in this guideline will become part of criteria applied to land disposal of wastewater solids. It is to be expected, however, that wastewater solids management will become the responsibility of the newly created State Solid Waste Management Board; therefore, the Division of Water Quality will probably wait until the State Solid Waste Management Board's new standards are adopted.

The State Health Department has, at the request of the State Solid Waste Management Board drafted tentative minimum standards for "Sewage Sludge Treatment and Land Application". These proposed standards are even more limiting than the EPA policy statements. For example, the first standard indicates that to prevent undue risks to the human food chain and health, sewage sludge spread on land shall meet the minimum criteria indicated in Table VII-3. These criteria would, for example, rule out the use of all the present wastewater solids from the EBMUD because of their high cadmium content.

Table VII-3. Proposed State Minimum Standards for Sewage Sludge to be Spread on Land[a]

pH	6.5 or greater
zinc	2,000 mg/kg dry wt.
copper	800 mg/kg dry wt.
nickel	100 mg/kg dry wt.
boron	100 mg/kg dry wt.
lead	1,000 mg/kg dry wt.
mercury	10 mg/kg dry wt.
cadmium	0.5% of zinc

[a]Source: Reference 31

Other limitations being proposed by these standards have to do primarily with the elimination of any possibility that pathogens will come in contact with humans or any product used for human consumption. This includes pasteuization, composting or long-term storage (at least 3 years) of digested sludge prior to its sale, use for general landscaping, playgrounds, athletic fields or other applications to land without further restrictions. Specific uses, such as golf courses, public lawns, parks and freeways, receive special considerations. When liquid sewage sludge is applied to land for any purpose, it must be spread thinly so as to dry completely within four days or be mixed into the soil within four days. Liquid sludge application procedures must minimize the formation of aerosol droplets. These preliminary standards are now under review by the State Health Department (SHD) and from discussions with the staff it can be concluded that the revised standards will eliminate any specific limits on concentration of heavy metals in wastewater solids applied to land. Based on the current thinking of the SHD staff regulation of heavy metals aspects falls under the jurisdiction of State Department of Agriculture and the U.S. Food and Drugs Administration. However the revised draft will impose strict requirements relevant to pathogenic organisms in bagged sludge intended for distribution to the public. Sterilization or long-term storage requirements will also be imposed on digested sludge applied to agricultural lands. Exceptions to these requirements will be made for small scale experimental projects.

AIR QUALITY CRITERIA RELEVANT TO WASTEWATER SOLIDS DISPOSAL OPERATIONS

Wastewater solids treatment, transport and disposal operations can create stationary or mobile sources of air pollution. The discussion in this section is limited to the effect of wastewater solids reduction processes such as incinerators which are classified as stationary sources of air pollution.

The Environmental Protection Agency (EPA) is authorized by the Clean Air Act of 1970 to regulate disposal of waste materials including wastewater solids by burning methods. In addition the Act requires EPA to promulgate national emission standards for hazardous air pollutants. Standards developed by EPA for control of emissions from stationary sources of air pollution are summarized in Table VII-4.

Available data on particulate matter emission and opacity of the stack flue gases indicate[32] that these criteria can be met by properly designed incineration facilities.

Provision is made in the federal legislation for delegation of authority to the states to implement and enforce the federal standards. In California the State Air Resources Control Board has been authorized by EPA to issue emission standards for mobile and stationary sources of air pollution. The State Air Resources Control Board carries out its functions in conjunction with several Air Pollution Control Districts which have primary responsibility for regulation of stationary pollutant emission sources in their areas of jurisdiction. Standards promulgated by the Bay Area Air Pollution Control District require that gases discharged from sludge incineration facilities should not: (a) contain particulate matter at a rate in excess of 1.30 lb/ton of dry sludge input and (b) exhibit 20 percent opacity or greater except where the presence of uncombined water causes a failure to meet this requirement.[34] These standards are similar to the standards developed by EPA which are summarized in Table VII-4.

Table VII-4.. National Emission Standards for Stationary Sources of Air Pollution[a]

Regulated element	Limitation
Particulate matter	0.65 g/kg dry sludge input (1.30 lb/ton dry sludge input)
Opacity	$\leq$ 20 percent (except where failure to comply is due to the presence of uncombined water)
Beryllium	The least restrictive of <10 grams per 24-hour period or An ambient concentration in the vicinity of the stationary source of 0.01 ug/m^3 average over a 30-day period
Mercury	<2,300 grams per 24-hour period

[a]Source: Reference 33

WASTEWATER SOLIDS DISPOSAL TO WATER

Although disposal of wastewater solids to freshwater lakes and streams is no longer considered acceptable, the case for ocean disposal is still being debated. Some major coastal urban areas of the United States are still studying the effects of their ocean disposal programs; however, most urban areas recognize social pressures for abandoning this disposal method and are searching for alternate wastewater solids management methods. The 1972 Marine Protection, Research and Sanctuaries Act gives the EPA the power to stop the flow of wastewater solids to all navigable bodies of water in the United States. In addition international agreements restrict disposal of wastes to ocean waters beyond the territorial limit of United States. The California State Water Resources Control Board has also prohibited any new discharge of wastewater solids to any body of water within the state and has set a deadline for termination of existing ocean dumping operations.[35] EPA has not formally prohbibited ocean disposal of wastewater solids, however, dischargers are discouraged from initiating any new dumping operations.

CHAPTER VIII

ALTERNATIVE WASTEWATER SOLIDS MANAGEMENT SYSTEMS

Due to the large expanse of the nine county county San Francisco Bay Area, the large number of treatment facilities, and also because of the diversity of physical and demographic conditions encountered in this area it is improbable that a single sludge management system could be devised which would optimally meet the wastewater solids disposal needs of all areas within this region. More probably a number of management systems will be developed which will be tailored to the specific conditions of various subregional areas.

Several sludge management systems can be potentially implemented in this area. Alternative sludge management systems for San Francisco Bay Area are listed below:

1. Landfill Disposal.
2. Existing Practices.
3. Agricultural Reuse of Wastewater Solids.
4. Incineration.
5. Ocean Disposal.
6. Energy Recovery.
7. Fertilizer Recovery.
8. Pyrolysis.
9. Bay Delta Levee Reinforcement.
10. Horticultural Reuse.

A brief discussion on each of the above alternatives is presented in the following sections. Detailed cost data for regional management systems utilizing some of the above alternatives were developed in this study to provide an overview assessment of costs and impacts. However basic cost information is not available for large scale systems utilizing pyrolysis, energy recovery, fertilizer recovery, or Bay Delta levee reinforcement alternatives. For these systems cost data are presented for pilot scale systems or on the basis of unit costs reported in the literature or provided by manufacturers.

Evaluation of Alternative Wastewater Solids Management Systems

The objective of the evaluation process discussed in this section is to provide a basis for comparison of various alternatives. However due to the lack of detailed cost data on most of the alternatives considered herein and because of the cursory level of evaluation of other alternatives it was not possible to develop any recommendations on the desired sludge management system for San Francisco Bay Area. Selection of appropriate sludge management systems for each subregion in the study area should be carried out during the course of a comprehensive area wide wastewater solids management program.

Economic evaluation of some of the alternative wastewater solids management systems was carried out on the basis of cost curves used in the basin planning process as well as other available information relevant to capital, operation and maintenance costs for wastewater treatment facilities. This information was supplemented by material contained in the Corps of Engineer's Triple S Study. Standard cost estimating curves used in the economic evaluation are shown in Figs. VIII-1 through VIII-5.

All cost data are based on an Engineering News Record Index of 2400. Annual construction costs were obtained by amortizing initial capital costs over a period of 30 years for land disposal systems and 20 years for incineration system. An annual interest rate of 6 percent was used in the calculation process. Although differing useful life periods were used for different alternatives comparisions can be carried out on the basis of total annual costs. All facilities were assumed to have a design capacity matching the projected waste loads in year 2000. Operation and maintenance costs were calculated by estimating the average quantity of solids processed during the period 1975-2000 and inflating annual O&M costs by seven percent of 12.5 years. Total annual costs were obtained by summing annual capital and O&M costs.

For purposes of this report subregional wastewater management systems recommended in the Water Quality Management Plan for San Francisco Bay Basin (Basin 2) have been used as a basis for evaluating alternative wastewater solids management systems.

Alternative 1 - Landfill Disposal

This is the most widely practiced method of wastewater solids management in the study area and elsewhere in the nation. Currently more than 55 percent of the wastewater solid loads removed at wastewater treatment plants in San Francisco Bay Area are disposed in landfills. However, as the capacity of close by landfills become exhausted municipal sludges must be transported over ever increasing distances to find suitable final disposal sites. Moreover the significant loss of resources incurred when usable products are buried in natural or man made depressions in the ground does not commend this method of sludge disposal for other than short range, stop gap, or emergency use purposes. Exceptions to this conclusion would arise when excessive costs would be incurred to salvage the reusable products contained in wastewater solids generated at outlying small treatment plants.

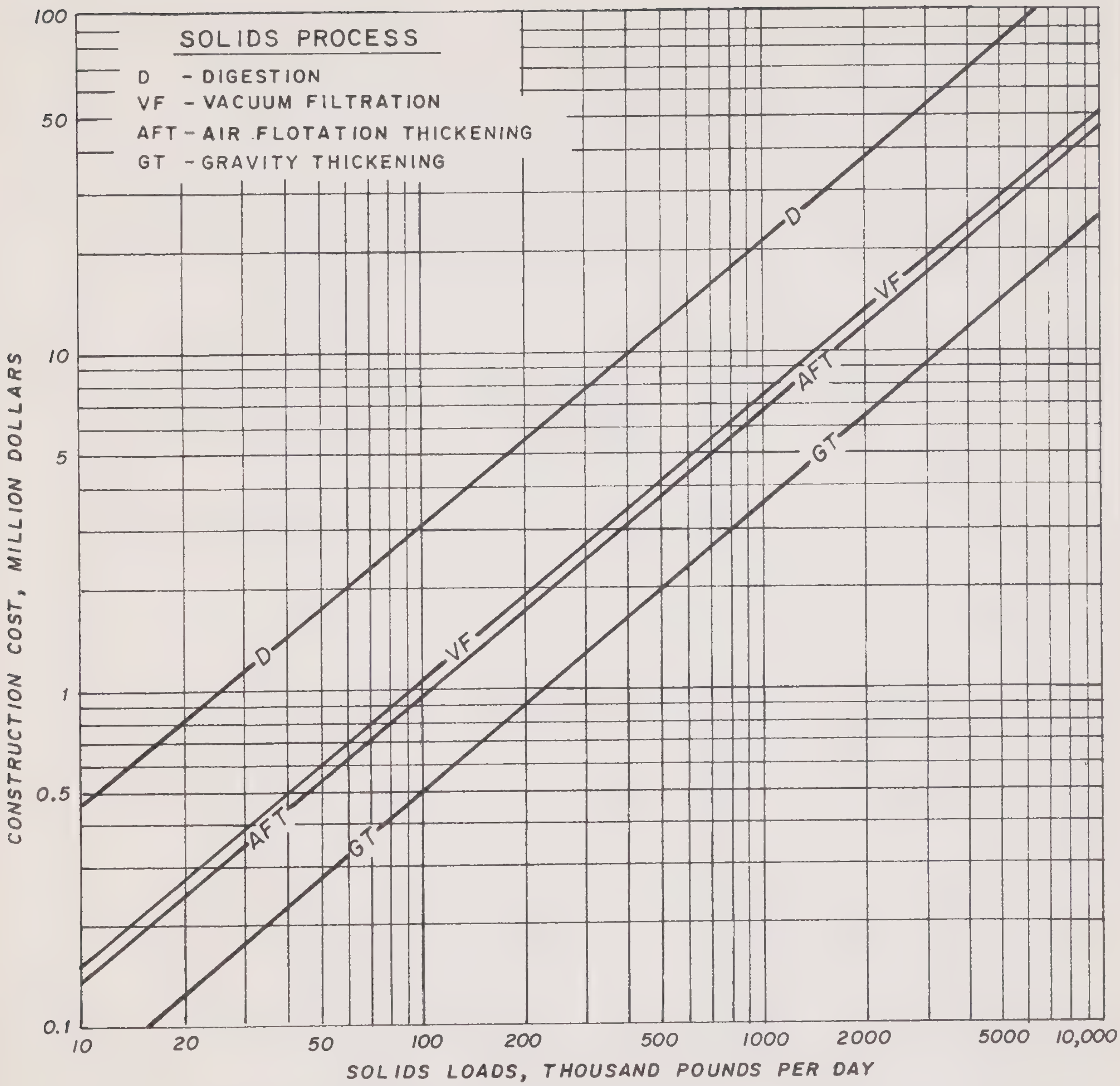


Fig. VIII-1. Construction Costs for Solids Processing Plants

Source: Reference 1

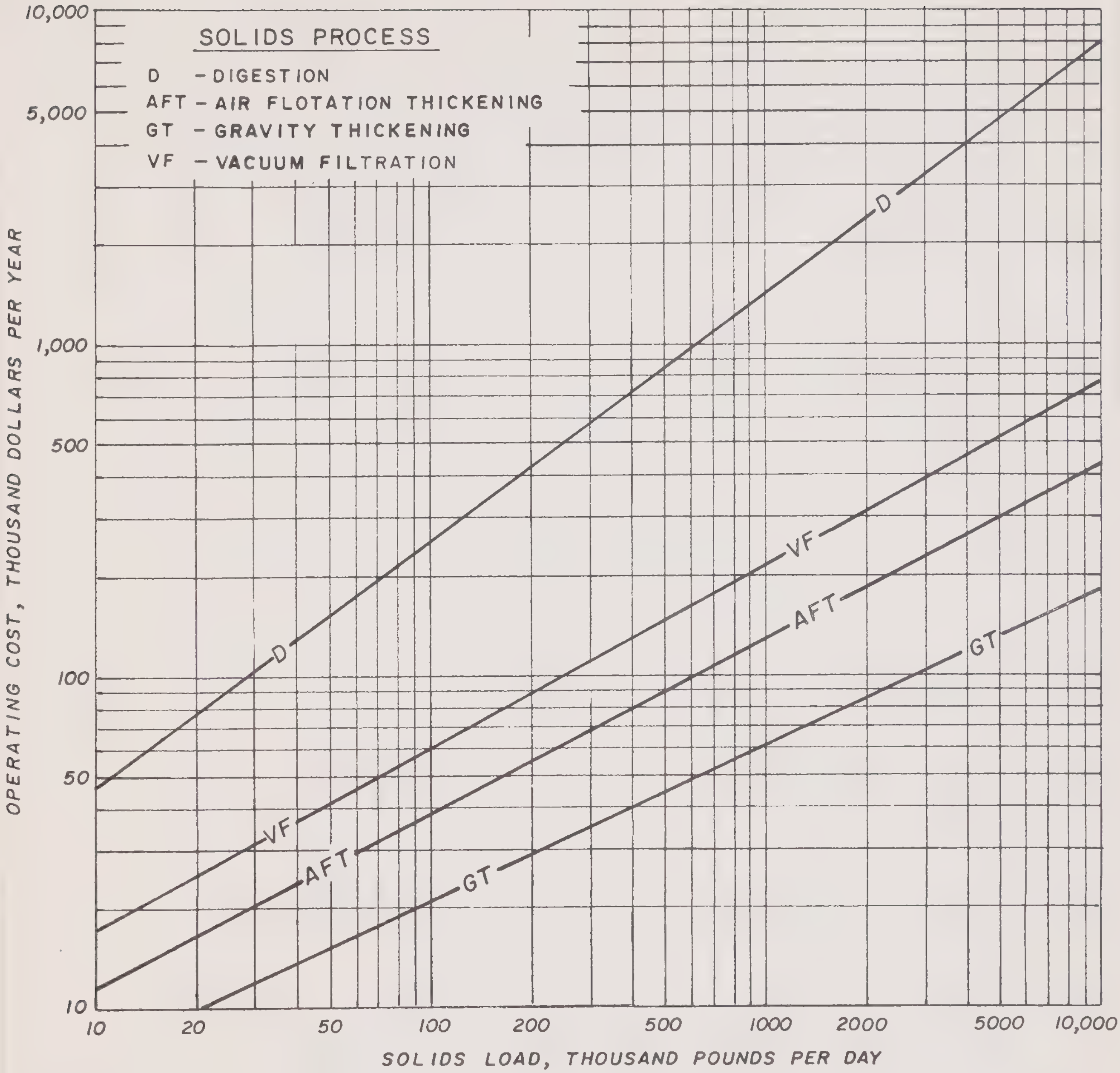
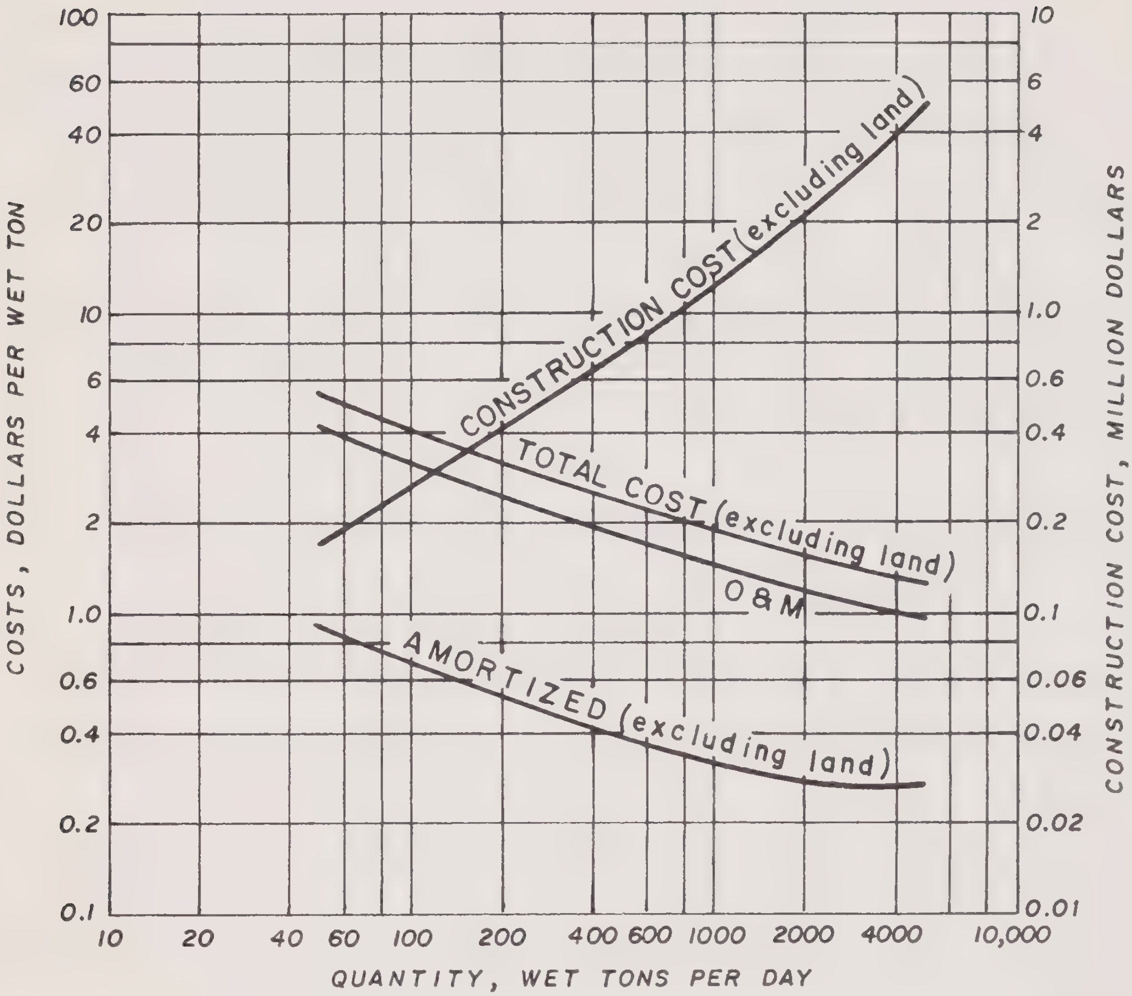


Fig. VIII-2. Operating Costs for Solids Processing Plants

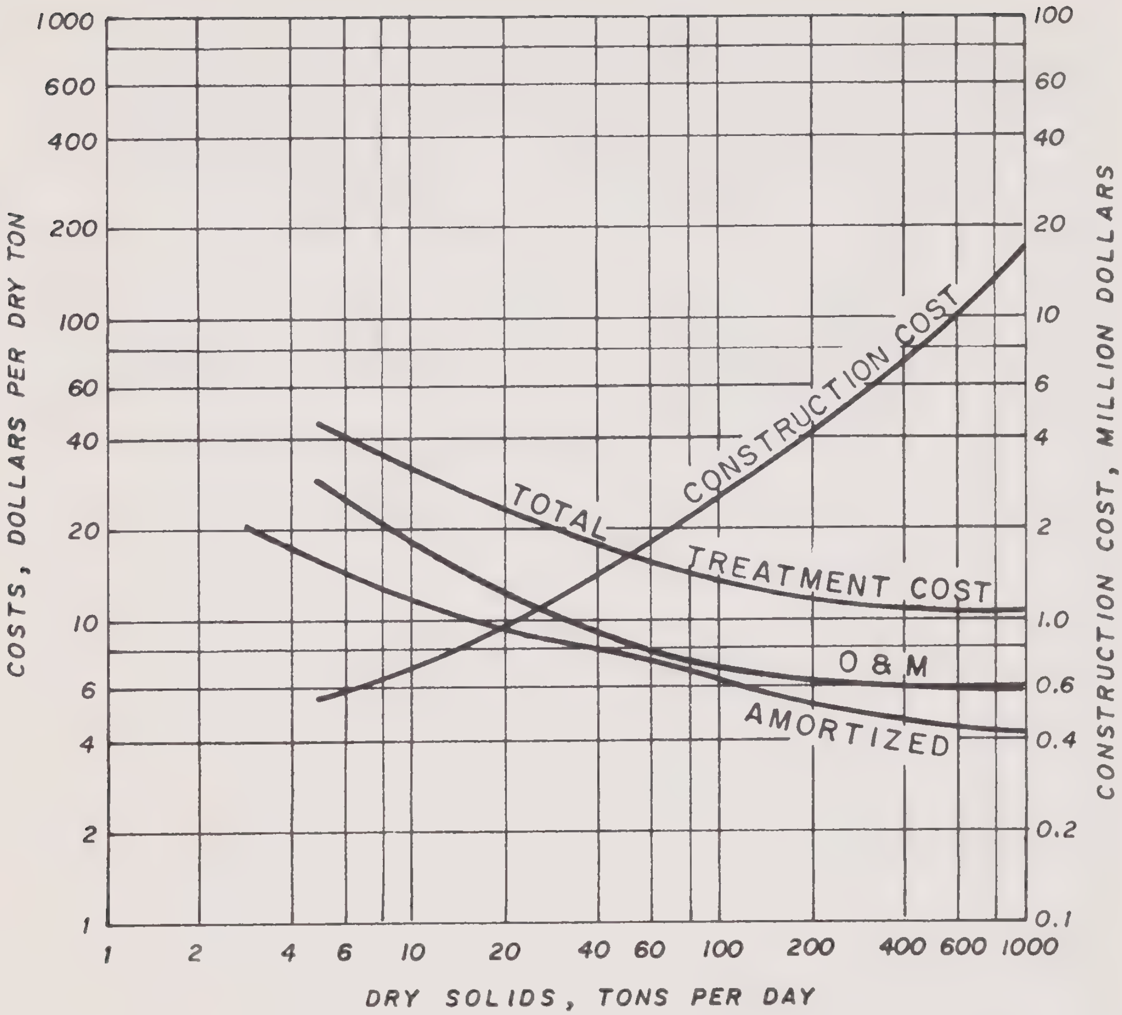
Source: Reference 1



NOTES:

1. Minneapolis. Mar., 1972. ENR Construction Cost Index of 1827.
2. Amortization of 7% for 20 years.
3. Labor rate of $6.25 per hour.
4. Quantity assumes 6-day work week.
5. Wet sludge must be considered for cost per ton.
6. Source: U.S.P.H.S. and Stanley Consultants.

Fig. VIII-3. Capital and O/M Costs for Sanitary Landfills



NOTES:

1. Minneapolis, Mar., 1972. ENR Construction Cost Index of 1827.
2. Amortization at 7% for 20 years.
3. Labor rate of $6.25 per hour.
4. Exhaust gas scrubber and enclosing structure included.
5. Costs do not include deodorization of gases: where required, add $4 to $10/dry ton.
6. Source: EPA Cost and Manpower Report and Stanley Consultants.

Fig. VIII-4. Multiple Hearth Incineration Costs

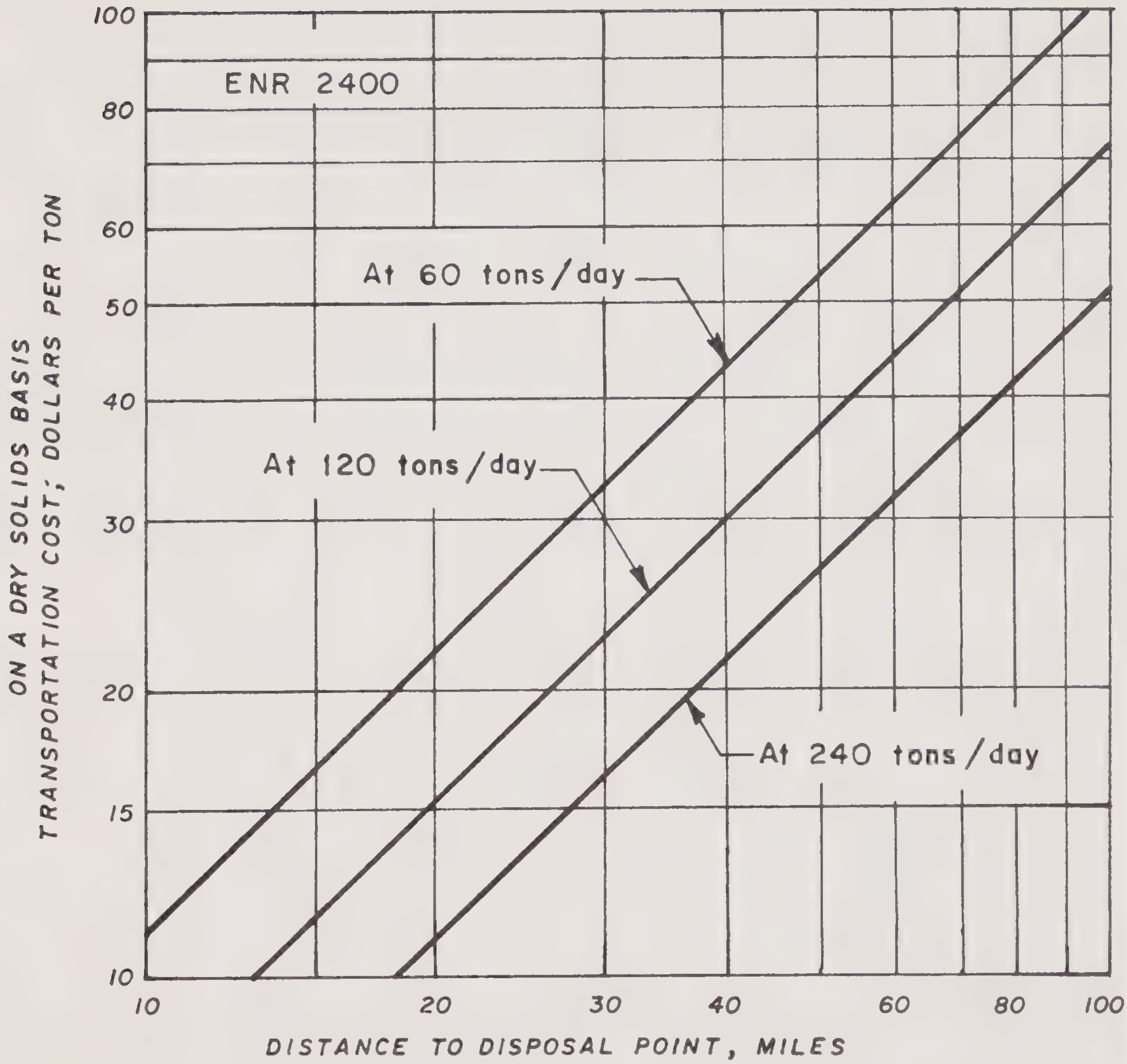


Fig. VIII-5. Cost of Pipeline Transport of Liquid Organic Sludge

The major cost item associated with landfill disposal practices consist of the cost of treatment and transport of wastewater solids. Digestion and dewatering is required under most conditions for disposal in a landfill. Cost of transport varies as a function of the mode and distance of transport. Total regional costs for this alternative are probably close to those for the following alternative.

Alternative 2 - Existing Practices

More than 55 percent of existing wastewater solids loadings are disposed of in landfills. About 10 percent of existing loadings are incinerated and the remainder is either stored in lagoons or is air dried and used for landscaping and other soil conditioning purposes. For purposes of this analysis it is assumed that public use of biologically stabilized wastewater solids which have not been sterilized will not be allowed in the future. Based on this assumption all agencies currently using this method of disposal will be required to transport their sludges to a landfill disposal site. However all other existing practices were assumed to remain unchanged over the planning period.

In this alternative sludge handling facilities of existing plants which have been included in the recommended plan for municipal wastewater treatment facilities will be enlarged to accommodate projected solid loads through year 2000. Digestion is used at most of the existing plants for volume reduction and digested sludge is either disposed of on site or at a local landfill. Where solids are removed from the site moisture content will be reduced by mechanical means or through the use of drying beds.

Cost data for this alternative are presented in Table VIII-1. High operation and maintenance costs are associated with this approach since existing facilities are retained and relatively minor investments for additional treatment capacity are necessary. Solids disposal costs were calculated on the basis of the assumption that all sludge will be transported from the site to a landfill. This differs from the existing practice at some municipal wastewater treatment facilities where a portion or all of the dried sludge is used by local residents or nurseries. However in all probability in the future other methods of disposal will have to be implemented by these wastewater management agencies because as the volume of sludge increases with time it will become progressively more difficult to use the present give away method of final disposal. For all subregional treatment plants where design of additional facilities has been finalized or where these facilities are currently under construction such as EBMUD and the Central Contra Costa Sanitary District no capital costs were assigned to the planned facilities. However the cost of needed additional future facilities were incorporated in the total cost for these treatment plants.

For new subregional treatment plants initial capital costs of significant magnitude will be incurred for construction of sludge treatment and disposal facilities. From the data presented in Table VIII-1 it can be observed that this alternative will require a total annual cost of $24,000,000.

Table VIII-1. Estimated Cost Data for Existing Sludge Management Systems in San Francisco Bay Area

Sewerage Agency	Initial capital cost 1,000 dollars	Operation and maintenance cost 1,000 dollars/year	Residual disposal cost 1,000 dollars/year	Total annual cost[a] 1,000 dollars/year
Alameda County				
Livermore	1,087	176	48	255
Valley Community Services District	1,666	276	78	397
EBMUD	1,266	2,497	1,323	2,589
City of Hayward	482	249	115	284
Oro Loma Sanitary District	185	462	84	475
City of San Leandro	b	374	123	374
Union Sanitary District Alvarado Plant	2,368	520	130	692
Subtotal	7,054	4,554	1,899	5,066
Contra Costa County				
City of Brentwood				
CCCSD	10,104	(592)[c]	50	0
Pittsburg-Antioch	839	142	77	203
San Pablo Sanitary District	1,032	174	69	249
Richmond Municipal Sanitary District	416	227	100	257
Subtotal	12,391	(49)	296	709
Marin County				
South Central Marin	2,533	224	181	408
North Marin	1,844	139	100	273
Subtotal	4,377	363	281	681
Napa County				
Napa Sanitary District	1,996	321	83	466
St. Helena		4	1	5
Subtotal	1,996	325	84	471
City and County of San Francisco				
Southeast Plant	4,350	2,321	1,070	2,637
Richmond Sunset Plant	2,299	784	272	971
Subtotal	6,649	3,105	1,342	3,608
San Mateo County				
SSF/Airport/San Bruno	b	267	159	267
City of Millbrae	b	156	65	156
City of Burlingame	b	220	95	220
City of San Mateo	962	134	2	218
Redwood Shores	3,166	945	467	1,175
North San Mateo Co.	716	288	41	340
City of Pacifica	688	249	122	299
City of Half Moon Bay	103	16	-	24
Subtotal	5,635	2,275	951	2,699
Santa Clara County				
City of Palo Alto	692	214	4	274
San Jose - Santa Clara	6,566	2,671	1,456	3,148
City of Sunnyvale	193	354	269	364
Gilroy - Morgan Hill	1,789	295	102	425
Subtotal	9,240	3,534	1,831	4,211

Table VIII-1 (continued). Estimated Cost Data for Existing Sludge Management Systems in San Francisco Bay Area

Solano County				
City of Benicia	317	49	21	71
Fairfield - Suisun Sanitary District	795	138	2	207
Vallejo Sanitary District and FCD	1,340	211	6	308
Vacaville	85	275	25	281
Subtotal	2,537	673	54	867
Sonoma County				
City of Petaluma	1,046	215	64	1,261
Sonoma Valley County Sanitary District	440	125	39	565
City of Santa Rosa Laguna Plant	3,331	593	232	3,924
Oakmont				
Winsor County Water District				
Healdsburg	2	15	9	15
Subtotal	4,819	948	344	5,765
Grand Total	54,698	15,728	7,082	24,077

[a]Capital costs were amortized at 6% over a 30-year period

[b]No additional capital improvements will be required

[c]Income derived from an energy recovery system based on the assumption that solid fuel can be obtained at $4.20/ton from a municipal solid waste resource recovery plant

Alternative 3 - Agricultural Reuse of Wastewater Solids

Large areas of agricultural land are located within the San Francisco Bay Area and in neighboring areas to the south, north and east of this region. Digested sludges could be applied to some of these lands to provide nutrients for crop growth and act as a soil conditioning agent. EBMUD has conducted extensive field investigations on agricultural reuse of municipal sludges and is still continuing this pilot field program. Extension and continuation of this program will provide design parameters and operational criteria for development of prototype land application projects. Environmental and public health concerns have arisen due to high concentrations of some heavy methods and presence of pathogenic organisms in digested municipal sludges. Criteria applicable to land disposal of municipal sludges have been discussed in detail in the preceding chapter.

In order to implement a land application alternative in the San Francisco Bay Area sludge may have to be transported to agricultural areas in Solano or San Joaquin counties or to both of these counties as well as to suitable areas elsewhere in the study area.

For example digested wastewater solids could be transported by pipeline to two main barge stations - one located at San Francisco and a second located at the Oakland outer harbor. From here sludge can be barged to land disposal sites located around the periphery of the San Francisco Bay Area.

Solids are transported with a moisture content of 94-96 percent to minimize headloss in pipelines. Application at the disposal site is assumed to be by spray irrigation at an application rate of 5 dry tons of solids per acre per year. Barge and rail transport costs were assumed at 24 and 30 dollars per dry ton of sludge, respectively.

Cost data for the land disposal alternative evaluated here are presented in Table VIII-2. Land disposal is competitive with other methods of solids disposal as shown by the total average annual cost of about $18,000,000 as compared to $24,000,000 per year for the existing disposal approach. Additional economies may be achieved through more detailed analysis since relatively conservative transport costs were assumed for pipelines and barge transport elements. Capital cost of planned improvements already approved for construction facilities under construction such as those at EBMUD and CCCSD were not included in this cost analysis.

Three options to the basic land disposal plan were investigated. These alternatives included the transport of sludge from Redwood Shores and/or East Bay Dischargers south to San Benito County and from Marin and Sonoma county plants to the northern delta area. In each case higher costs were apparent which usually resulted from increased unit costs for rail shipment in lieu of barging. For example, if residual solids from the new Redwood Shores plant is conveyed by pipeline to the San Jose - Santa Clara plant for subsequent rail transport to the San Benito County land application site transportation costs amount to $271,000 per year as compared to $236,000 per year for transport to the northern delta site by pipeline and barge. Also annual cost increases of $38,000 per year will result if solids from San Leandro, Hayward and Union SD treatment plants are transported south to the San Benito County site instead of transporting these solids to the northern delta site. This increase is less than 20 percent of the total annual cost and a more detailed evaluation should be performed to arrive at the optimum cost solution. In Marin and Sonoma counties increases in transportation costs will result if wastewater solids are transported to the northern delta agricultural lands due largely to the additional transport distance and the requirement for barge hauling as well as pipeline transport to a barge loading station located near Point San Quentin. Average annual transportation costs for this option were $352,000 as compared to $281,000 which would be incurred annually if this sludge were tansported by pipeline to a land disposal site in north Marin County.

It is estimated that about 26,000 acres of land will be required for land disposal of municipal sludge through the year 2,000. If this land is to be maintained for permanent agricultural use according to the EPA standards sludge spreading operations at these sites should be discontinued at the end of the planning period and additional new land should be acquired for sludge disposal purposes at that time. The above estimate is fairly conservative because no allowance is made for on site storage facilities, buffer strips, etc. More exact data on the acreage requirements should be developed during the detailed regional study.

In this alternative all existing treatment plants equipped with sludge incineration facilities were assumed to use these facilities for sludge disposal purposes through the planning period.

VIII-2. Estimated Cost Data for Regional Land Disposal of Municipal Wastewater Sludge in San Francisco Bay Area

Regional Wastewater Treatment Plants	Average Annual Cost,[a] 1,000 dollars/year: Anaerobic digestion	Pipeline transport	Consolidated barge and rail transport	Land cost[b]	Land application cost	Total annual cost 1,000 dollars/year	Land area requirement acres
Southeast	1,420						
Richmond / Sunset	548	57					
SSF/Airport/San Bruno	209	16					
Millbrae	58	5					
Burlingame	104	12					
Redwood Shores	584	102					
N. San Mateo	182	13					
Pacifica	149	14					
Subtotal	3,254	219	1,060	616	87	5,236	8,800
Richmond	325	-					
Hayward	302	57					
San Leandro	181	21					
Union Sanitary District Alvardo Plant	532	119					
EBMUD	1,098	24					
Subtotal	2,438	221	914	527	76	4,041	7,600
Livermore	191	13					
Valley Community Services District	299	36					
Subtotal	490	49		58	9	606	830
Pittsburg-Antioch	139	17		22	3	181	300
San Pablo	273	3	63	37	5	381	530
Central Marin	430	113					
N. Marin	294	44					
Napa	299	63					
Petaluma	172	12					
Sonoma Valley	109	14					
Santa Rosa	575	35					
Subtotal	1,879	281		184	26	2,370	2,600
San Jose - Santa Clara	1,264						
Sunnyvale	197						
Subtotal	1,461	9	800	376	53	2,699	5,400
Gilroy - Morgan Hill	299	12		33	5	349	470
Subtotal	9,908	811	2,769	1,814	258	15,560	25,930
Plants with existing incineration facilities	Incineration 1,000 dollars/yr			Landfill 1,000 dollars/yr			
Palo Alto	501			18			
San Mateo	456			9			
Oro Loma	362			9			
Vallejo	362			5			
Fairfield	446			6			
CCCSD	0[c]			17			
Subtotal	2,127			64		2,191	
Grand Total	12,360	811	2,837	1,917	264	18,054	26,530

[a]All costs were amortized at 6% over a 30-year period.

[b]Land costs were amortized at 6% interest over an infinite economic life period.

[c]For details refer to Table 1.

Alternative 4 - Incineration Disposal System

This method can achieve the maximum reduction of municipal wastewater solids. However the major disadvantage of incineration is its potential for creating a source of air pollution and its high energy consumption. Moreover recoverable materials contained in wastewater solids are irretrievably lost during the incineraation process.

In this alternative it was assumed that all subregional treatment plants will be equipped with sludge vacuum filters and incineration facilities. This assumption is not very valid because it is improbable that this method of disposal will be universally selected in San Francisco Bay Area. However the excercise was carried out to provide a measure of the cost of the incineration disposal option: Capital, O&M and ash disposal cost data for this alternative were developed and are presented in Table VIII-3. From this data it can be observed that sludge incineration has the lowest total annual cost ($17,000,000 per year) among the regional alternatives costed in this study, excluding ocean disposal. However, environmental factors such as concern for air pollution may outweight the economic advantage of this method of sludge disposal.

Alternative 5 - Ocean Disposal

New discharges of wastewater solids to waters of the state is prohibited by the State Water Resources Control Board.[35] However the potential for use of the ocean disposal method still exists and it is conceivable that regulatory restrictions on this method of disposal may be relaxed in the future. The major disadvantage of the ocean disposal method is the environmental hazards associated by the public to this method of disposal. Until definitive data is available to enable careful evaluation of the environmental impact of this disposal method it is improbable that any new ocean dumping operations will be approved by state or federal regulatory agencies.

Costs for the ocean disposal alternative were developed for comparison purposes for major subregional systems in the study area and are summarized in Table VIII-4. These costs are associated with barging of digested sludge from the same docking facilities utilized for the land application alternative.

Data presented in Table VIII-4 show that the total annual cost of ocean disposal system will be about $15,425,000 per year which is lower than the cost associated with other alternatives for which detailed cost data have been developed in this study.

Alternative 6 - Energy Recovery

Dewatered wastewater solids when incinerated with shredded municipal refuse will provide a source of energy which could be utilized for heating, cooling or electric power production purposes. A feasibility investigation carried out by the Central Contra Costa Sanitary District showed that such a system could be economically self sustaining by providing electric power and heat energy for use of wastewater treatment plants or other municipal and industrial activities. This alternative has a great potential in the current period of energy crisis. However air pollution potential of this system could rule out its universal application to all subregions

Table VIII-3. Estimated Cost Data for Regional Incineration Facilities for Disposal of Wastewater Sludge in San Francisco Bay Area

Sewerage Agency	Initial capital cost for vacuum filtration & incineration 1,000 dollars	Operation and maintenance cost 1,000 dollars/year	Hauling and landfilling costs 1,000 dollars/year	Total annual cost 1,000 dollars/year
Alameda County				
Livermore	1,546	153	2	290
Valley Community Services District	2,178	202	2	394
EBMUD	7,296	974	18	1,628
City of Hayward	1,973	258	3	433
Oro Loma Sanitary District	1,091	265	3	363
City of San Leandro	1,670	199	2	346
Union Sanitary District Alvarado Plant	2,809	372	4	621
Subtotal	18,563	2,423	34	4,075
Contra Costa County				
City of Brentwood				
CCCSD	10,104	(592)[b]	50	0
Pittsburg-Antioch	1,546	155	2	292
San Pablo Sanitary District	1,929	214	2	384
Richmond Municipal Sanitary District	c	232	4	236
Subtotal	13,579	9	58	912
Marin County				
South-Central Marin	2,358	270	3	479
North Marin Plant	1,834	183	2	345
Subtotal	4,192	453	5	824
Napa County				
Napa Sanitary District	2,096	197	2	382
Subtotal	2,096	197	2	382
City and County of San Francisco				
Southeast Plant	7,382	1,029	19	1,691
Richmond Sunset Plant	2,835	348	5	600
Subtotal	10,217	1,377	24	2,291
San Mateo County				
SSF/Airport/San Bruno	1,710	210	2	361
City of Millbrae	1,018	85	1	175
City of Burlingame	1,211	132	2	240
City of San Mateo	924	278	4	362
Redwood Shores	2,865	1,198	5	1,453
North San Mateo Co.	1,448	161	2	289
City of Pacifica	1,246	134	2	245
City of Half Moon Bay				
Subtotal	10,422	2,198	18	3,125
Santa Clara County				
City of Palo Alto	1,248	433	6	548

Table VIII-3.(continued). Estimated Cost Data for Regional Incineration Facilities for Disposal of Wastewater Sludge in San Francisco Bay Area

Sewerage Agency	Initial capital cost for vacuum filtration & incineration 1,000 dollars	Operation and maintenance cost 1,000 dollars/year	Hauling and landfilling cost 1,000 dollars/year	Total annual cost 1,000 dollars/year
San Jose - Santa Clara	10,044	1,088	20	1,984
City of Sunnyvale	2,534	281	4	506
Gilroy - Morgan Hill	2,191	177	2	370
Subtotal	16,017	1,979	32	3,408
Solano County				
City of Benicia	1,069	80	1	174
Fairfield - Suisun Sanitary District	1,670	202	3	350
Vallejo Sanitary District and FCD	1,406	207	4	334
Subtotal	4,145	489	8	858
Sonoma County				
City of Petaluma	1,546	140	2	277
Sonoma Valley County Sanitary District	1,246	106	1	216
City of Santa Rosa Laguna Plant Oakmont Winsor County Water District	3,535	320	4	632
Subtotal	6,327	566	7	1,125
Grand Total	85,558	9,691	188	17,000

[a]All facilities were amortized at 6% interest rate over a 20-year economic life period.

[b]Income derived from an energy recovery plant based on the assumption that solid fuel can be purchased at $4.20 per ton from a municipal solid waste recovery plant.

[c]No additional capital improvements will be required during the planning period.

Table VIII-4. Estimated Cost Data for the Ocean Disposal Alternative in 1,000 of dollars

Subregional area	Anaerobic digestion	Pipeline transport	Assumed one way barging distance, miles	Consolidated barge transport	Total annual cost
Ocean disposal					
East Bay Dischargers	2,338	241	25	541	3,120
San Francisco and San Mateo County Dischargers	3,254	219	25	621	4,094
San Jose and Sunnyvale Dischargers	1,461	9	47.5	764	2,234
Marin and Sonoma County Dischargers	1,304	246	40	320	1,870
Subtotal	8,132	695		2,246	11,318
Land disposal[a]					
Livermore and Valley Community Services District					606
Santa Rosa					659
Gilroy-Morgan Hill					349
Subtotal					1,614
Incineration[b]					
Palo Alto					519
San Mateo					465
Oro Loma					371
Vallejo					367
Fairfield					452
CCCSD					17
Subtotal					2,191
Grand Total					15,123

[a]For details refer to Table VIII-2

[b]For details refer to Table VIII-3

within the nine county area. Moreover planning for this system must be coordinated with municipal refuse management activities which may impose probable institutional constraints under some circumstances. Cost data on the energy recovery system evaluated for the Central Contra Costa Sanitary District show that for an energy recovery system using 426.5 tons per day of solid fuel (shredded refuse) and receiving 165 tons per day of chemical sludge with about 56 percent moisture content will require a capital expenditure $10,000,000 and an annual operating cost of $177,000. However this system would result in an annual saving of $1,379,000 in natural gas and electric power costs.[36] This cost saving can be utilized for financing the refuse preprocessing operations at the rate of $4.20 per ton of solid fuel. So the energy recovery system could be self sustaining under conditions encountered in CCCSD. However this plant requires significant quantities of energy for recalcining purposes and the economy of these operations would not be applicable to plants without the recalcining requirements.

Alternative 7 - Fertilizer Recovery

Various methods have been proposed for packaging municipal wastewater solids as a marketable fertilizer product. These methods may involve composting or heat drying of digested sludges for subsequent fortification and packaging purposes. However the major uncertainty involved in the implementation of a system of this type would be the availability of assured markets for the end product of the management system. In the past many municipal refuse composting plants have been forced to close down due to their inability to compete with commercial fertilizers. The following methods can be used for fertilizer recovery purposes: (1) flash drying, (2) rotary hot air dryer, (3) organic recycling unit, (4) air drying and (5) composting. The first three methods require considerable amounts of energy for production of each pound of nitrogen fertilizer. For example flash drying uses 30,000 to 35,000 BTU per lb of N, rotary hot air dryer uses 59,000 BTU per lb of N and organic recycling units require 22,000 to 25,000 BTU per lb of N generated. Air drying and windrow composting do not require any significant energy input. The energy consumption associated with these methods results from spreading removal or mechanical mixing operations. The major disadvantage of fertilizers produced from wastewater solids is the low nutrient content and bulkiness of these products. However due to increasing costs of chemical fertilizers and material shortages encountered in the chemical fertilizer industry more favorable market conditions may develop for fertilizers produced from wastewater solids and municipal refuse materials. Air pollution potential of heat drying methods should also be considered in selection of a fertilizer recovery method.

Alternative 8 - Pyrolysis Method

Pyrolysis is a destructive distillation process which reduces wastewater solids to combustible gases, inert residues and secondary by-products of commercial value. This method of resource recovery can be used without creating air pollution problems as serious as those associated with incineration processes. EBMUD in association with Pacific Gas and Electric Company has recently completed an investigation to determine the feasibility of using the pyrolysis method to recover energy from municipal refuse and wastewater solids.[18] Results of this investigation indicate that wastewater solids may cause serious operating problems and impose economic penalties in a refuse pyrolysis plant. However pyrolysis of municipal refuse is deemed technologically feasible. Capital costs associated with

a 1750 tons per day pyrolysis plant are in the neighborhood of $34,000,000 and the annual operation and maintenance cost of this system is about $3,500,000. In addition it is estimated that a capital expenditure of $4,000,000 will be required for developing a separate gas distribution system for the low BTU content gas produced from the pyrolysis plant.[38]

Alternative 9 - Bay Delta Levee Reinforcement

A potential method for reuse of wastewater solids in the San Francisco Bay Area consists of composting a mixture of digested municipal sludges and shredded municipal refuse. The resulting compost can then be transported to the delta area and used for reinforcing various levees and raising the elevation of the delta islands. Preliminary feasibility investigations have been carried out on this project by the Bay Delta Resource Recovery Demonstration Project Board and preparations for conducting a pilot scale field experiment are currently under way. If this project proves to be environmentally sound and economically feasible significant quantities of municipal wastewater solids as well as municipal refuse generated in the study area could be used for the prototype project. The estimated cost of the Bay Delta Pilot Scale experiment project has been included in the feasibility report prepared for this project.[39] According to these estimates a 1,000 tons per week composting plant will require a total capital cost of $2,250,000. In addition a capital cost of $942,000 will be required for processing and transport of raw materials, monitoring of operations, and barging of the final product to the delta. The amount of sewage sludge used in this system is undetermined so no definitive costs can be developed on the basis of sludge utilized. Annual operation and maintenance cost of this system is estimated at $1,844,000 per year of which $692,000 is associated with the operation of the composting plant.

Alternative 10 - Horticultural Reuse

Reuse of stabilized wastewater solids for soil conditioning and fertilization purposes in landscaped areas such as golf courses, freeway medians, parks, cemetaries, forests, etc. is a viable method for wastewater solids disposal purposes. For many years the City of San Francisco has been using a portion of its treated wastewater and stabilized wastewater solids in the Golden Gate Park for irrigation and soil conditioning purposes, respectively. State Department of Highways has indicated that there are over 30,000 acres of landscaped freeway medians in California. There are large acreages of golf courses, cemetaries, forests and parks in and around each metropolitan area. Properly treated wastewater solids can be used to significant benefit on these lands which are not devoted to production of crops entering the human food chain. Heavy metals restrictions imposed on the use of wastewater solids on agricultural lands may be further relaxed when the use is intended for nonfood producing lands. However limitations relevant to sterilization or long-term storage of wastewater solids for elemination of pathogenic organisms would, most probably, also apply to this method of solids reuse and disposal.

CHAPTER IX

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This report contains the results of an overview study of municipal wastewater solids management operations in the San Francisco Bay Area. The emphasis in this report is placed on management of organic municipal wastewater solids removed during wastewater treatment processes. Considerable industrial activity is undertaken in the study area and significant residual solids loadings are probably generated by these industries. Also significant solids loads composed of scum, screenings and grit are removed at municipal wastewater treatment plants. However due to the lack of readily available data and because of time and budgetary constraints no detailed investigations were carried out on management methods used for handling of these residual solids. A comprehensive survey of all existing municipal sludge treatment and disposal operations was carried out in this study. The survey was initially conducted by BASSA through the use of mailed questionnaires. The information contained in these questionnaires was later tabulated and missing or additional data were obtained by personal contacts with various wastewater management agencies. Data on existing sludge loadings were developed on the basis of the information supplied by the various agencies and are summarized in Table IV-1 in Chapter IV. A wide diversity is observed in the quantity of solids produced for each million gallons of wastewater treated at various plants in the study area. This wide range is in the main part due to the lack of exact monitoring of the quantity of wastewater solids produced at wastewater treatment plants and variable operating and design characteristics. Results of the survey show that currently approximately 11,700 tons of raw wastewater solids are produced each day in the nine county San Francisco Bay Area. This quantity is composed mainly of water and contains only 330 tons of dry solids. The treated sludge loads amount to 8,700 tons per day which contain about 250 tons of dry solids.

Wastewater solids are treated in the majority of municipal treatment plants by anaerobic digestion method but a few plants utilize incineration facilities for reduction of residual solids. More than 55 percent of the digested and dewatered wastewater solids loads are currently disposed of in landfills, however, at several of the smaller treatment plants air dried solids are used as a soil conditioner by the public or by commercial enterprises. Lagooning is also used for biodegradation, evaporative drying and storage of digested wastewater solids at a number of treatment plants. Only 10 percent of the present municipal solids loadings is currently incinerated in the San Francisco Bay Area.

Projected municipal wastewater solids loadings were developed on the basis of wastewater flow projections presented in the basin plan for the San Francsico Bay Area. In developing solids loading projections uniform unit loadings were assumed for the future. Also the subregional wastewater treatment strategy recommended in the basin plan was used as a basis for determining wastewater

solids loadings in the various geographical subareas in the San Francisco Bay Area. Based on this analysis it was estimated that raw municipal wastewater solids loadings, containing approximately four percent dry solids, will increase from a level of 11,700 tons per day in 1974 to 19,000 tons per day in 1985 and 24,200 tons per day in year 2000. Due to probable errors in estimating existing loadings the projected increase in solids loadings is disproportionate with the increase in wastewater flow rates.

Several potential methods for wastewater solids disposal or reuse were investigated in this study and detailed cost data were developed for four alternative wastewater solids management systems. The annual cost of these systems varies from $24,000,000 per year for the existing system to $15,425,000 per year for the ocean disposal alternative. Annual cost of the alternative system based on agricultural reuse of digested municipal wastewater solids was estimated at $18,000,000 per year whereas a system utilizing solids incinerators at all treatment facilities would require a cost of $17,000,000 per year. If incineration facilities are enlarged to receive municipal refuse and if energy recovery facilities are incorporated in these incinerators it is probable that an economically self-sustaining solids management system could be developed for certain plants in the study area. However the economic benefits of such a system must be carefully weighed against possible detrimental environmental effects related to emission of air pollutants.

Conclusions

A diverse number of wastewater solids treatment and disposal method are practiced in the San Francisco Bay Area, however, the majority of wastewater treatment agencies generating 55 percent of the existing solids loading dispose of their treated solids by landfilling method. All but 10 percent of the remaining loads are stored in lagoons or are air dried and stockpiled at the plant site. Although some of these solids are reused by local residents and commercial nurseries the bulk of the load constitutes a disposal problem and is eventually disposed of in a landfill or spread on other types of land disposal sites.

There is a need for conducting a comprehensive wastewater solids management program in San Francisco Bay Area because although significant wastewater management planning efforts have been undertaken in this area during the past decade the question of wastewater solids management has been mainly ignored during these planning processes. In the absence of any coordinated planning program individual wastewater management agencies have tried to cope with the mounting wastewater solid loads by the most readily available method at their disposal. In a majority of cases landfilling has provided an acceptable although a temporary method of sludge management. Although landfilling method may have constituted the cheapest means of wastewater solids disposal at one time this condition is no longer valid in all cases because promulgation of increasingly restrictive requirements for landfill disposal and ever increasing transport distances are imposing a heavy cost burden on wastewater solids management operations. Therefore there is an obvious need for evaluation of all available options for wastewater solids management purposes. Such an evaluation should be carried out on a regional basis and should be coordinated with municipal refuse

disposal problems. In general wastewater solids and municipal refuse disposal problems are handled on a day to day basis while it is hoped that a technological breakthrough will provide the final answer for these waste management problems. It is probably safe to state that the technology is now available for devising more rational methods for the total solid waste management problem. However before significant commitments of resources can be made to other alternative systems an overall review of the nature and scope of the problem must be undertaken on a regional basis.

The following general conclusions can be developed on the basis of the results of this overview study:

1. More detailed basic data on wastewater solids loadings and characteristics, as well as data on potential land spreading sites, and energy and other resource markets are needed to enable informed decision making relevant to alternative wastewater solids management systems. In addition the entire topic of industrial residual solids needs to be addressed, since data on this subject is scarce.

2. The landfilling method is not amenable to resource conservation and may have direct and indirect detrimental environmental effects. However the potential exists for recovery of useful resources from wastewater solids generated in the San Francisco Bay Area by use of Alternative solids management systems.

3. No single basin wide system can be devised that would optimally meet the requirements of all subregions in this area. More probably a number of subregional systems will be needed which would utilize the most suitable technology for management of wastewater solids. For example whereas land spreading methods may be suitable and economical for east and north bay areas. Other resource recovery systems utilizing combined solid waste and wastewater solids would probably constitute a more suitable management system for the San Francisco Subregion. However, a regional approach is needed to determine optimal groupings. Development of optimal solutions and detailed evaluation of facility requirements as well as determination of the cost of such subregional facilities can only be carried out in the context of a basin wide wastewater solids management planning program.

4. Questions related to the institutional as well as financing aspects of wastewater solids management systems need to be evaluated during a comprehensive planning study.

5. Wastewater solids management planning activities must be closely coordinated with county wide solid waste management planning programs. Although informal contacts were maintained with the planning groups engaged in county wide solid waste management planning activities during this study a closer coordination with these activities will be required for developing comprehensive wastewater solids management plans.

6. Cursory examination of several alternatives indicated that cost savings can be achieved by discontinuing sludge landfilling operations and utilizing land spreading or energy recovery management alternatives. More detailed work is required in this area to evaluate the potential of other available alternatives such as pyrolysis, horticultural reuse, etc. and to refine cost data on the alternatives evaluated in detail in this study.

7. Regulatory constraints and standards of varying stringency are imposed on different wastewater solids disposal or reuse systems. Landfilling criteria and standards, can be met with little difficulty so long as a landfill of proper classification is available for sludge disposal purposes. However, limitations imposed on toxic metal concentrations in wastewater solids applied to land or emission requirements imposed on solid incineration or energy recovery facilities may be more difficult to meet and will necessitate careful evaluation of the feasibility of these management alternatives.

In summary it can be concluded that in order to develop viable subregional wastewater solids management programs in the San Francisco Bay Area a comprehensive study of this problem should be undertaken in which various aspects of solids handling, treatment and final use or disposal will be evaluated and recommendation for physical facilities as well as institutional and financing aspects of the management system will be developed.

Recommendations

The following recommendations have been developed on the basis of the results of this overview study:

1. A comprehensive area wide wastewater solids management planning study should be undertaken in the San Francisco Bay Area to evaluate the long range planning direction for management of an estimated 1985 daily load of 19,000 tons of raw wastewater solids. In this planning study all potential reuse alternatives should be fully investigated and feasibility of implementation of various alternatives in different geographical subareas of the Bay Area should be evaluated.

2. It is imperative that some pilot plant investigations are carried out prior to commitment of significant resources to new and untested large scale technical reuse systems. In as much as significant beginnings have been made in this direction by several agencies in the study are inclusion of these activities within the overall management program would only be logical. In this regard the following specific projects could be funded and continued as part of the area wide wastewater solids planning program:

    a. Land spreading investigations carried out by EBMUD in Solano County.

    b. Bay Delta resource recovery demonstration project carried out by the Bay Delta Resource Recovery Demonstration Project Board.

c. The energy recovery pilot program carried out by Central Contra Costa Sanitary District.

d. East Bay Municpal Utility District and Pacific Gas and Electric Company's pyrolysis investigation project.

However, it is important that these activities are carried out within the context of the overall planning study and are aimed at providing technical data to enable selection of the most suitable technical alternative for various subregions in the study area.

3. Funding for the required planning activity as well as the concurrent pilot plant investigations should be obtained through the clean water grants program. Funds from the State Solid Waste Program could also be used for conducting pilot plant projects that relate to the overall solids waste management problem. Funds for the Bay Delta Resource Recovery Demonstration Project have already been allocated by the state legislature, however, complete implementation of this project is contingent upon securing matching federal funds.

4. BASSA, as a regional planning agency, is ideally situated for conducting the overall wastewater solids management planning study. However, close coordination with all affected wastewater agencies as well as all county solid waste management agencies will be required to ensure the development of a plan which will be responsive to the needs of municipal wastewater dischargers. This objective can be achieved by conducting the solids management study on the pattern of wastewater management studies which were carried out for 15 subregions in the San Francisco Bay Area. The wastewater solids management problems of each subregion will be evaluated separately and solutions to these problems will be developed within the confines of the given subregion. Additionally regional reuse alternatives will also be evaluated and ways in which several subregions would share common physical facilities for transport, processing or reuse of sludge will be explored. In this manner the work in each subregion will be carried out in close coordination with the municipal wastewater management agencies included in that subregion while at the same time the planning activity will be carried out on a regional basis through the close involvement of Bay Area Sewage Services Agency. Due to the constantly recurring local and regional solutions in this approach centralization of all planning activities will be essential to the successful conduct of the planning study. Preparation of a number of separate and unrelated planning documents addressing only the problems of a small segment of the study area will not be very productive under this planning process. The key to the development of a successful plan will be in the ability of the planner to constantly compare subregional and regional solutions and arrive at the best possible solution for each given condition.

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